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GILBERT'S

RAILWAYS

OF

ENGLAND AND WALES.

With a Map.

LONDON:
. GRATTAN, 51, PATERNOSTER ROW.
1838.

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THE

RAILWAYS OF ENGLAND;

CONTAINING

AN ACCOUNT OF THEIR ORIGIN, PROGRESS, AND PRESENT STATE;

A DESCRIPTION OF THE SEVERAL PARTS OF A RAILWAY, AND A HISTORY OF THEIR INVENTION;

TOGETHER WITH

A Map;

WITH ALL THE LINES CAREFULLY LAID DOWN, BOTH OF THOSE ALREADY CONSTRUCTED, AND THOSE WHICH ARE PROJECTED, OR IN COURSE OF EXECUTION.

LONDON:
E. GRATTAN, 51, PATERNOSTER ROW.
1839.

ADVERTISEMENT.

The present little Treatise has been compiled by the Author of the "ZOOLOGICAL GARDENS," to illustrate Mr. Gilbert's excellent *Map of the Railways of England and Wales*. It has been the endeavour of its writer to compress into the space allotted to him an account of the cause, the origin, the history, and the constituents of those important means of transit, and though he has not been able to enter into the subject as he could wish, and does not pretend, with engineering skill, to instruct those better informed on the subject than himself, he yet trusts that all the information which is necessary to make any person acquainted with the progress and origin of railways will be found in his little volume. All the best authorities that were necessary for fulness and accuracy have been carefully consulted, and he has endeavoured to convey the statements they contained in a manner that would render them pleasing to the general reader.

THE

RAILWAYS OF ENGLAND.

CHAPTER I.

PRELIMINARY RETROSPECT.—BUSINESS; ITS AMOUNT AND REQUIREMENTS.

A BARREN detail of facts upon any subject, no matter what, must, at the best, be uninteresting, and cannot very often be found useful. It may, it is true, lead the thoughts of the reader to valuable results if he will take the trouble, and happens to be in possession both of the time and the ability to turn it to account. But if the latter of these qualities be such as the generality of readers are endowed with, the former is an attribute of circumstances which but few comparatively can command, and it becomes, therefore, not only the interest, but the duty of any one professing to give information on a popular subject, to do so in such a way as shall render his labours pleasing as well as

instructive, and should he fail in accomplishing the first of these desirable attainments, it is at least incumbent upon him to save all who shall peruse his work the fatigue of going over any ground not absolutely necessary for them to traverse in coming at the only legitimate end of all writing—public or private benefit.

We do not then deem it irrelevant, in this confined treatise on the important subject of Railways, to take a hasty glance over the state of the people before they were invented. It would, indeed, be impossible, without such a retrospect, rightly to understand the influence they possess over the welfare of the country at large, and the extent to which it has been exercised in altering the occupations, or abridging the labours of its inhabitants.

No where has the change of manners from the customs of the period of feudal darkness, when the cultivation of a military spirit, and the pursuit of the arts of war, comprised all that was deemed honourable in the personal engagements of men, and when the pursuit of letters was, at the best, considered puerile, and the knowledge of them almost a folly by the bold spirits who found their most agreeable occupation in the practice of exercises which had the fatal contests of the battle field for their prototype, and the instantaneous infliction of death as the highest attainment of their study—when mechanical device was, in its most ingenious production, a matter for applauding wonder only among the plebeian and the despised, coldly regarded by the

learned, and contemned by the noble and the brave; when commerce brought but slow accumulations of wealth, and when its profits were not only tardy, but generally unstable, and often not a little degrading—to the period when we see around us on every side the most complex state of society which the world has ever witnessed, wherein the elegant, the high-born, and the refined depend for so much of their enjoyment, nay for no small portion of the comforts they feel indispensable to existence, upon those low and sordid pursuits of trade which have, during the last two hundred years, been eliciting, through the blessing and under the governance of Divine Providence, the powers of human intellect in all its wondrous and varied faculties, till the accomplishment of anything within the range of physical creation is hardly thought impossible; and which, by its persevering and energetic pursuit, has carried this country to the permanent hold of a pitch of greatness, and an extent of empire unparallelled in earthly annals—no where, we say, has this change from chivalric usage to the habits of modern civilization been so gradual, yet so perceptible, as in England.

The civil wars which for a hundred and sixty years had desolated every province of the land, and steeped its soil in blood, excited, if they did not tend to create, the warlike spirit and warlike habits which were necessary to carry them on. To wield a weapon was alike the employment of yeoman, serf, and noble, and the leaguered castle or the tented field the homes to which

they had been so long accustomed, that at last they became even a delight. But the attainment of Henry of Lancaster to the throne set aside the cause for war, and his politic sway encouraged the continuance of peace, and made it desirable as well as permanent, by rendering the callings that could be followed in it, honourable as well as profitable and safe.

The reign of his arbitrary but able son tended materially to propel that which his father had begun. The religious disputes which his selfish and ungovernable passions aggravated, even if they were occasioned by him, rendered the value of intellectual prowess evident, and when he, the first sovereign, who since the days of Alfred had entered on this novel arena, became a champion in the moral jousts of polemical controversy, an impetus was given to the public mind which soon developed its consequences in the increased intensity of the struggle, which at length ended in the perfect triumph of the cause of truth. But if it was as greatly influential in effecting this great good, it accomplished one, also, of almost equal value in the fit preparation which it became for the more general diffusion of learning in the time of Edward VI.

The religious persecutions of Mary's reign, diastrous as they were to the individuals who suffered from their rigour, appear, at least, to have wrought out this benefit for mankind, for their atrocity put even cruelty to the blush, and rendered torment odious in the sight of men. Neither do we find either moral or political struggles,

after her death, conducted on the same principle as they had been before, for though the arduous contest which followed nearly a century later, and which terminated only with the conclusion of the bleak tyranny which arose upon the death of Charles, was one of bloody reference, yet its objects and its principles were very different to the wars of the Roses, and were, indeed, efficient, in their degree, in establishing the supremacy of intellectual over physical conflict.

The futility of such a strife itself was proved by the hasty close of its results; and after the darkness of fanatical gloom which brooded over the land had cleared away, we find the habits of thought which took utility and truth for their base, more general, the dispositions of the people more peaceful, and their inclination for agriculture and commerce in commoner existence, and more frequently followed. Even the very attire of the people partook of the change, it lost the varied, but picturesque, appearance of feudal habit, and assumed the less pleasing, but more convenient, costume which forms the link between the dress of olden time, and that of the present day. The circumstances which occurred during the period that Elizabeth held the reins of power, were especially calculated to promote the public weal, give security to property, and impel national industry. Religious contentions were subsiding so far as their malignancy was concerned, and the effect of their existence was being felt in the enlarged acquaintance of the body of the people with

the elements of their faith, and the evidence on which its credibility depended.

Learning had received an impulse which was felt in the increased civilization that was diffused throughout every portion of the country, an effect which the character of Elizabeth, particularly, was likely to induce; half chivalric, half controversial, placed in circumstances of great difficulty, and peculiar hazard, from which the exercise of consummate prudence, conjoined with uncommon boldness, and unwonted decision, could alone, humanly speaking, deliver her, full opportunity was allowed for the development of her singular characteristics, and these in turn became influential in the promotion of similar features in the mental organization of her subjects. The open-hearted recklessness which had distinguished the English character, and which seems the almost necessary attendant on a military career, became subdued into the calmer, but not less candid, quality of sober good faith. The invincible courage and increasing energy which had won fields against tenfold odds were softened down into the decided perseverance, and springing enterprize by which the annals of British commerce have been distinguished.

Nor was the influence of the characters of her ministers, perhaps, less permanent or strong. Crafty, close, far-seeing, and prudent, but yet faithful to his mistress, Burleigh was a man of that grade which requires the passage of some centuries to produce; he was respected—he was feared—he was reverenced. No

portion of the state but felt the inquiry of his scrutinizing supervision, and when at his death the body of this founder of his family was removed to that resting place whence it shall only arise to behold the glories of the dreadful morn when the firmament shall pass away like a scroll, and the elements shall melt with fervent heat, he left an impress of sober steadiness of thought behind him upon the characters of his countrymen, which, if originally inherent in the national mind, was certainly much confirmed by the deportment of this singular but lofty-minded man.

Yet, though thus powerful in his individual capacity, he was still more so as chief member of a body of individuals who were called upon to support the burthen o state affairs at a period of no common difficulty, and to devise and conduct measures of immense importance, and which required singular penetration and care for their management; Sir Francis Walsingham had lent the valuable aid of his very considerable talents to promote the wise settlement of the country, and with Sir Nicholas Bacon, admirably seconded Burleigh, both in his service of the Queen, and in his plans for the national welfare. The influence they unitedly obtained could not but be greatly instrumental in the modification of the English character. Moderate, sober views of things succeeded to the feverish excitement that had agitated the people throughout the length and breadth of the land, the engagements of commerce offered a more pleasing and profitable field for exertion than any

military prowess had ever enjoyed, while the value of the milder virtues began to be deeply appreciated, and the virtues themselves proportionably encouraged. Examples of their existence were found among the higher classes, while those whose position obliges them to look up to their superiors for guides had obtained a considerable degree of instruction in the new modes of living, and, moreover, were willing to be led. The desire for peaceful pursuit happily conjoined with the opportunity for following it, and thus the people in the majority of communities at length came to settle down to their home projects; and trade, which had formerly been only a rare or a mean engagement, swelled into an extent that required the exercise of noble abilities and extensive capital to carry it on, and became invested, by its incidental circumstances, with a dignity to which it would not otherwise have been entitled.

Humanity has inherited too much of littleness in its composition, from the degradation of original sin, not to be easily moved by anything which shall minister to its selfishness and pride, and, as in proportion to the contumely with which any course of life is regarded, it will eschew that course, so, just in proportion as any one shall be generally esteemed, will it be ready to embrace and follow it. The adoption of trade as a pursuit had an expansive influence, and that which was esteemed soon became common, and at length was not only adopted but honoured.

According as attention was turned to commercial

affairs, the means for carrying them on would be naturally increased. As obstacles presented themselves, the means for obviating them would be assiduously sought. Ability would be prized in proportion to the necessity for it, and would offer itself for employment in proportion to the amount of remuneration which it could obtain. The natural facilities of the country, whether in the shape of raw material, or the employment given by converting it into a more valuable product, would be eagerly made available for the purposes of profit, and we find that such in fact was the case.

The particular facilities of Britain are great, greater perhaps than those of any other country, or they have, at least, been more generally developed. It possesses all the essentials for the furtherance of mechanical ingenuity, and the employment of manufacturing industry. Coal and iron, the two chief agents, the one in the formation of machinery, and the other in its use, are found in abundant quantities beneath the soil, and in such close contiguity that they are readily made to assist each other.

Only a slight review of the transactions of our manufacturers will render the necessity for mechanical agents apparent, and to what extent they have been introduced will be conceived, when it is stated, that there are steam engines now at work within the realms of Great Britain which possess powers equal to the labour of four millions of individuals, and, in thus rating them, we believe we are much understating the truth.

The extent of our manufacturing resources is, therefore, extraordinary, nor is it likely, for an incalculable period, to be reduced. Of these resources, coal is perhaps the most necessary, and the most unbounded; without it machinery could neither be constructed nor worked, and the present consumption of it is immense. Prior to the time of Charles I., it was used but seldom even as fuel, a prejudice prevailing that its use was injurious, which was so far influential that it prevented the adoption of coal for that purpose for a number of years. The expence of wood, however, and the increasing scarcity of timber in some measure compelled its employment, and experience proving that the smoke of it was not so deleterious as had been imagined, its ascendancy was soon generally and permanently secured, and now it is the only species of fuel used in London and other large towns, and in the thickly inhabited districts of the country.

The amount of sea borne coal brought into the port of London is estimated at 2,050,000 tons, and the total amount used in Great Britain, exclusive of that exported to foreign countries, is calculated at 15,580,000 tons, though, as Mr. M'Culloch thinks, considerably below the real amount, a conclusion, which observation warrants, and in which we decidedly coincide. Dr. Cleland estimates that the coal consumed in Glasgow, in 1831, a place giving a fair example of the amount expended in our manufacturing processes, at a time when the amount must have been very much less than

it is at present, was 437,000 tons. The coal consumed for domestic purposes is stated to be after the rate of about a ton of coals a year for each individual, or something like sixteen and a half millions per annum, exclusive of that employed in the service of steam vessels, stationary and locomotive engines, manufactories, blast furnaces, and other like purposes. The quantity consumed in Scotland must be approaching to 3,000,000 tons for private use, besides that used for business.

The quantity used in the manufacture of iron is about 3,850,000 tons, or about 5½ tons for each ton of iron, of which about 700,000 tons are yearly made. Mr. Kennedy has calculated the quantity of coal burnt in the manufacture of cotton at after the rate of 1,000,000 tons a year. Its consumption in the woollen and silk trades must amount to as much as 500,000 tons, and not less than half that amount, or rather 300,000 tons, are used in the smelting of ores in Cornwall. The copper and brass manufactures are said to require as much; 300,000 tons are said to be used in the salt works of Cheshire, Worcestershire, &c., and not less than 500,000 tons are employed in the several lime works in different parts of the country. Altogether it is believed that nearly 23,000,000 tons of coal are yearly consumed in Great Britain; supposing this quantity, therefore, on an average to cost the consumer ten shillings a ton, a return amounting to 11,500,000*l.* is yearly produced to the owner from this article alone,

What then, must be the aggregate of mechanical contrivance to get, to convey, and to deliver this enormous quantity of goods?

For such a consumption, we might well suppose an almost endless supply would be necessary, and therefore be reasonably fearful that it must shortly grow scanty, and in the end cease; a circumstance which in a country like this, where the daily support of so large a portion of the inhabitants depends upon the employment afforded by our manufactories, would be to be deplored as a misfortune of the utmost moment. But from fears of this kind we are happily relieved. Mr. Taylor, whose researches on this subject have obtained for him well merited reputation and confidence, gives the following estimate of our nothern coal fields, a report sufficiently encouraging to relieve us from all alarm on the subject of its failure. He states, that in Durham there is an extent of country stretching from *South Shields* southward, to *Castle Eden,* twenty-one miles; thence westward to *West Auckland,* thirty-two miles; northeastward from *West Auckland* to *Eltringham,* thirty-three miles; and then to *Shields,* twenty-two miles, making an area of 594 miles; and that in Northumberland from Shields northward, twenty-seven miles, by an average breath of nine miles, making an area of 243 miles, and with the field in Durham making an extent of land occupied by coal fields of not less than 837 square miles, of which, however, 105 have been already excavated. This space, he states, at a moderate estimate,

would yield 6,046,320,000 tons, adequate to supply the present vessels from the principal coal ports of the north for 1,727 years.

Besides this mass, however, there are extensive beds in the northern and western parts of Northumberland as yet unexplored, and in addition to this, Mr. Bakewell in his Geology, in a passage quoted by Dr. Buckland, in his evidence before the House of Lords, and therefore evidently approved by that eminent geologist, says, that the coal fields of Wales alone would supply the demands of the whole country for more than two thousand years. A period long before the expiration of which we may reasonably calculate the use of coal will be supplied in our manufacturiug processes by some chemical agent, even if it be not also superseded in a great degree for domestic purposes.

In Scotland the supply is neither so general nor so abundant, but it is nevertheless both plentiful and extensive. Were it not for the neighbourhood of this valuable mineral the manufactures of Glasgow and Greenock could never have progressed to the extent which they have so wonderfully attained. Mr. Buddle, one of the most experienced coal managers in the North of England, and having, perhaps, a more important survey than any other individual in existence, in his evidence before the House of Commons upon this article, gave from official documents a statement of the number of persons employed in this very essential branch of business in the district with which he is

connected. Those engaged under ground in the collieries on the banks of the Tyne are, men, 4,937; boys, 3,554; above ground, men, 2,745; boys, 718; making a total employed in both ways of 11,954. In the collieries on the Wear, there are 9,000 more employed, making an aggregate of 21,000 individuals employed in the coal trade in that district alone. In addition to these, however, there are to be added the watermen, seamen, and others employed in the conveyance of the article, amounting to 15,000; and he thus sums up the whole numbers engaged in the several departments. There are seamen 15,000; pitmen and people employed above ground at the collieries 21,000; keelmen, &c., 2,000; in London, whippers, lightermen, &c., 5,000; factors, agents, &c., on the coal exchange, 2,500, making a total together of 45,500, an immense number, and showing the existence of a business requiring the aid of every mechanical power that could be enlisted into its service, not only to expedite its conduct, but to carry it on even with common facility.

The next business most important for our consideration, as being immediately connected with the subject in hand, is the iron trade.

Documents have been left to prove that this natural product was early made available in this country, there being the means of certifying that iron works were established in the forest of Dean in Gloucestershire, as well as in other parts of the country, by its first invaders, the Romans. Kent and Sussex, especially, are

stated as having been the scenes of this manufacture, for not only was iron ore discovered there, but sufficiency of timber also grew close to the places where it was found for smelting it, the fuel being thus provided in the immediate neighbourhood of the sites where it was most wanted. The many purposes, however, to which wood was applied, gradually thinned the country of its super-abundance, and complaints were soon made of its application to any other purpose than those of domestic service; these received great weight from the circumstance that about the same time an immense quantity was required both for merchant ships and the navy. At length an act was passed in 1581, towards the latter end of the reign of Elizabeth, prohibiting the use of any but small wood in the manufacture of iron, and forbidding any new works to be erected within twenty-two miles of the city of London, and fourteen miles of the river Thames.

Necessity, however, has ever prompted the inventive faculty of man, and shortly after this prohibition took place the art of smelting iron with pit coal was discovered by Lord Dudley, a discovery to be ranked among the most important of those which have ever been achieved for promoting the general welfare. It is singular that his lordship took out the patent for this invention in the year 1619, about the time that the first railways were laid down, the manufacture of which was, perhaps, one of the most influential purposes to which it has ever been applied.

It would seem as if it were inévitable that the production of any great good should ever bring suffering and trouble upon its promoters, evincing even to the thoughtless observer, that there is an antagonist principle in existence ever ready to oppose and delay the welfare of the human race. Gallileo pined in a dungeon for the best years of his life. The obscurity of Copernicus during his earthly career can only be put into contrast with the splendour of a reputation which will last so long as the true system of the heavenly bodies shall be understood in its power, and be felt in its beauty. Shakspeare, unmatched in the colossal magnitude of his mind, came to this mighty metropolis an unknown and perhaps a despised adventurer, and even seems only to have owed the calm decline of his latter days to the singular prudence which he exercised in providing for his old age; and after Lord Dudley had made this discovery, fraught as it was with such invaluable consequence, his works were destroyed by the ignorant populace, and he himself almost ruined whilst endeavouring to perfect his process. Indeed, such an ill effect did it produce, that for several years the invention was nearly forgotten. The complaints of the destruction of timber did not therefore cease, and in consequence of the apprehensions entertained on that account, a law was passed in 1637, for prohibiting the exportation of iron without a licence. But this was not sufficient to abate the evil, and, as the minor mischief, it was contemplated to suppress the iron furnaces altogether, rather than suffer the fearful and

unprofitable consumption of wood which daily occurred. At this period more than two thirds of the iron used was imported, but at length the demand for it, coupled with the high price of timber, led the attention of persons connected with the manufacture to Lord Dudley's plan of smelting with pit coal, and about the year 1740, iron was successfully reduced by the new means. For thirty years, however, the furnaces in which wood was used successfully competed with those in the coal districts, and even after the metal had been largely produced in its manufactured state.

The demand occasioned by the late war, and the great difficulties it threw in the way of procuring iron, led to the extraordinary impulse which during its existence was given to the business of iron smelting. In 1740 the iron furnaces in England and Wales were estimated at fifty-nine, producing about 17,000 tons; but since then the increase has been gradually progressive, and is stated by Mr. Maculloch as having proceeded, till in 1750 it was 22,000 tons, and in 1788, 68,000 tons produced by eighty-five furnaces. In 1796 the number of furnaces had increased to 121, with a produce of 125,000 tons; in 1806 this was 250,000 tons from 169 furnaces. In 1820 the produce was 400,000 tons, and again in 1830 the number of furnaces was calculated at 376, with a produce of 678,417 tons, or which may be nearer the truth, 700,000 tons. Three-tenths of this is used in the state of pig or cast iron, and the rest is converted into wrought iron, being

used for those purposes in which tenacity and strength are chiefly required. The exports of pig iron amount to about 22,000 tons, and of the other sorts to about 133,000 tons, which at 10*l.* a ton, is worth as much as 1,550,000*l.* The whole value of all the iron manufactured in Great Britain has been estimated at 5,400,000*l.* Of that portion which is exported, the United States and France are the principal consumers; the greater part of it being doubtless used for the same purpose as that which absorbs so much in our own country—the manufacture of rods for railways.

Notwithstanding this exportation, a small quantity is still imported, chiefly from Sweden, for internal use, but the amount is already reduced to 16,000 tons, which is converted into steel for the manufacture of cutlery ware. The amount of capital, and the number of persons engaged in the conduct of a business of this magnitude, is of course very considerable. Mr. Maculloch, whose opinion on all matters of this nature is of the highest authority, estimates the former at as much as 7,000,000*l.*, and the number of the latter as not less than 220,000, and in corroboration of his view he cites a statement laid down in the work on the manufacture of iron, published by the Society for the Diffusion of Useful Knowledge, in which it is stated that the number of individuals employed in an establishment where there are five furnaces kept in blast, and a forge and mill capable of producing 200 tons of bar iron weekly, or about 100,000 tons per year. Women

and boys, as well as men are included in this statement, the latter constituting about one-eighth of the whole establishment.

Colliers, including road-men, horse-tenders, and sundry labourers	307
Miners, including stacking and loading the vein, road-men, horse-tenders, and sundry labourers	508
Furnaces, &c., including furnace labour, viz., keepers, fillers, refiners, cokers, pig-weighers, engineers, fitters-up, moulders, smiths, carpenters, sawyers, stablemen, brickmakers, masons, machine-men, carriers, &c. &c.	299
Forge and mill, with all the workmen engaged	205
Agents therein, overlookers and others . . .	31
	1350

a total of nearly 1400 individuals, who find direct employment.

The amount here produced is supposed to comprise about one-twentieth of the whole amount of iron manufactured in Wales and the adjoining county of Monmouth, by which it would appear the aggregate of individuals employed in this branch of business in the principality is about 28,000. These are said to be a little more than a third of the whole producers of the United Kingdom, which if correct, gives a combined total of 69,000 individuals directly engaged in the manufacture; and reasoning on the hypothesis that each of

these individuals has a family to support of three or four persons, we shall find that not less than from 210,000 to 220,000 human beings derive their support from this branch of the national business, and in thus stating, we are making the estimate at a low rate.

The iron works of the Welsh districts are chiefly comprised within the range of a very small extent of country, hardly exceeding twenty-five miles in length, and stretching from north-west to south-east. Within this confined extent the resources provided by subterranean wealth have been developed and applied with a rapidity and extent almost unparalleled. Merthyr Tidvil, the very heart of this immense district, was in the middle of the last century but an insignificant village, yet is now a place busy with all the operations of commerce, and containing a population of upwards of 22,000 souls; while the land and mines around the place for several miles, on which those colossal works are erected, which give employment to such an immense number of individuals, the proprietors of which having transactions with every quarter of the globe, were let on lease, in 1755, for a period of ninety-nine years for the insignificant sum of 200*l.* per annum. In 1801, Tredegar in Monmouthshire was an uninhabited district, yet has now, upon its lately bleak and waste domain, a population amounting to 6,000 or 7,000 individuals. Nor has the advance in other places been less hastily or less permanently prosperous.

Staffordshire, Warwickshire, and Shropshire, are the

chief sites for the manufacture of iron in England, and Colebrook-dale, where the business was first conducted to any extent, is still the principal seat in the last of these three counties.

The amount of iron ore smelted in Scotland, though apparently small compared with the quantity reduced in England, is still very considerable, amounting to as much as 75,000 tons in twenty-nine furnaces. But this amount which was stated to be the product in 1831, has since then been increased, and additional furnaces are yearly being brought into blast. Almost all the smelting establishments are situate on the Clyde, in the neighbourhood of Glasgow, though one of the principal ones, that of the Carron Company, stands on the Forth, and others of some extent exist at Muirkirk in Ayrshire. The bulk of business, however, is done near Glasgow, and from the advantages which the country around it enjoys in its rich beds of iron stone and pits of coal, that is the district where any considerable extension of the business may be expected to take place.

Iron stone was formerly smelted to some considerable extent in Ireland, especially in Munster, on the property of the Earl of Cork, which is said to have produced to its noble owner as much as 100,000*l.* a year, but owing to the great destruction of timber caused by the works, the business drooped, and at length altogether ceased; and though some very energetic attempts have been made within the last six or eight years to renew it, especially at Arigna, they have been unsuccess-

ful; and at the place we have named, chiefly through the hostility of the neighbouring peasantry, who were induced to choke the furnaces, through a dislike, it is supposed, which they entertained for the English Company by whom the business was attempted to be worked.

With this summary of the two branches of business mainly necessary to the construction of railways, and which, while they originated the necessity of such a means of transit by the amount of goods produced from them, also provided the materials for their construction, we might well be content, and leave our readers to estimate their value and their use without troubling them with any further details; but though these two branches of our national industry are primarily important in making us acquainted with every bearing of the subject in hand, they would leave the view of it yet very incomplete. Coequal with the coal trade in its requirement for a facility of this kind, the transit of metallic ore was prior in its demand for such a convenience. Indeed the first railway that was constructed, was for this very purpose, and we should then be giving but very partial data for the calculation of the importance of railways to the community, and offering only insufficient reasons for their establishment, if we did not also include in our notice of the causes of their origin, some statement of the amount and necessities of all our trading branches of the commercial interest. All have grown with the growth of our mercantile greatness, and

all have been proportionally instrumental in first impelling the invention of these new helps to the business world, and then compelling their adoption.

Of the mines and minerals of Wales, and the other iron districts of the United Kingdom, we have given a cursory notice, but the subterranean products of Cornwall also are almost equal in importance.

The results of *tin* and *copper* ore, which are the staple products of that last resort of the brave old Britons, when entrenched amid their bleak and barren wilds they set at nought the whole power of the Roman Empire, and made the soaring eagles of the haughty Cæsars to retreat from before them, have been gradually increasing since the commencement of the last century, but especially since the improvements of the steam-engine, by the use of the high pressure principle and the economising of power, introduced by the ingenuity of Wolf and Trevithick, supplied an increased means of raising ores from the lowest shafts, and together with the advantages of a more scientific sinking, securing, dialling and driving, enabled the hardy and intelligent miner to obtain, as well as to find, the riches of those hidden regions of the earth.

For the last ten years preceding 1834, the average produce of the tin mines of Cornwall are stated at 4,500 tons, worth from 65*l.* to 80*l.* a ton, or producing an aggregate value of about 330,000*l.* per annum. But this produce was, during the two or three years subse-

quent to the period we have named, considerably increased, not only from the quantity of ore obtained, but also from its greater purity and consequent value.

The most valuable product, however, of this interesting district are its copper ores; the ores of the two metals are frequently found together, and often intermixed, and it is singular, that though the value of tin had been appreciated from its earliest discovery, that of copper remained unknown or disregarded till the beginning of the last century, and only since that period have the copper mines of Cornwall been wrought with the spirit and industry which was commensurate with their importance. From 1736 to 1745, the quantity of fine copper produced from the ore raised was about 700 tons; from 1756 to 1765, the quantity was increased to 1800 tons; in 1775 the amount was still greater, being 2650 tons a year; again towards the close of that century it had become above 5,000 tons, and is now estimated as being more than 14,000 tons per annum.

There is also a good deal of copper obtained from the mines in Wales, a large quantity in the isle of Anglesey, where indeed the Parys mountain is said to be almost one mass of pure copper; an inconsiderable quantity in some inland parts of England, and a little in Scotland, and about 300 tons of the very best ore in Ireland.

The total produce is, as we have said, about, or upwards, of 14,000 tons a-year, which, at its usual price

of 95*l.* to 110*l.* a ton, will produce 1,300,000*l.*, or 1,400,000*l.* per annum. About 8,000 or 9,000 tons are exported, which are chiefly shipped to the East Indies, China, the United States, and France. Some foreign copper is imported, but it is simply for the purpose of re-exportation, and in no way interferes with the national trade in the article.

The capital employed in these extensive businesses is calculated at 2,440,000*l.*, and the number of individuals directly and indirectly engaged in working the mines, and in carrying their produce, are stated at 76,000, a number we should conceive considerably below that which ought to be expressed, though it be on Mr. Phillips' very highly respectable authority.

The produce of the lead mines is also very considerable, amounting, it is said, to upwards of 45,000 tons a-year. Of the money worth, no sufficient data can be obtained, for, perhaps, few articles are more variable in value. The localities where it is obtained are situated in Derbyshire, Cumberland, Northumberland, the western parts of Durham, in Flintshire, and at Leadhills on the confines of the counties of Lanark and Dumfries. All of them neighbourhoods either having railways already constructed, or likely shortly to have them.

Other sources of private resource, besides these, and those which may perhaps more properly be termed manufactures, exist in plenty and variety within the precincts of the British Isles, and all, more or less, have

a direct effect in exhibiting the necessity of new facilities for business, and impelling the application of invention to promote them. Among these, the *salt mines*, and the *fisheries* on our coasts, may be especially cited. The latter, more particularly, as being one of those means created by Divine Providence for the sustenance of the human race, calls for considerable attention. The supply of fish around the coasts of Great Britain is specified as being a continual harvest, and since the introduction of steam-vessels into our mercantile marine, it has been rendered available in a tenfold degree for the comfort and support of the country. Few places have partaken of the benefits more largely than the metropolis. The facility with which the commodity is obtained, and the predeliction of the people for a maritime life, has doubtless induced a very large consumption of it, but that has been chiefly confined to places to which water-carriage could readily be obtained. To such, steam-vessels could quickly, and, generally, easily convey it; but the advantage stopped there, and those inland places where fish would have been the mostly highly prized, yet remained excluded from the benefit which an abundant supply of wholesome and novel food would confer. Railways then came in as singularly valuable as a means of porterage. In a few hours, the fish caught on one coast could be readly transported to any other, or be distributed within a still shorter period throughout the villages and towns wherever a line was laid down that had,

or was connected with one that had, a terminus on the coast or near it. Thus would this great means of provision, not only be itself a direct advantage by its addition to the common stock, but also by its reduction of the price of provisions of other kinds.

How much sooner, for instance, could the fish caught in the Bristol Channel be transported by means of the Great Western Railway from Bristol to London, than by taking the circuitous route of the British Channel even by the fastest steamer that ever cleaved the waves? And how strongly, though in a minor degree, does the same position hold with respect to both the Brighton and Southampton Railways; as also with respect to the produce of the fisheries on the Norfolk, Suffolk, and Essex coasts by the Eastern Counties Railways.

Should even the encouragement afforded by this ready means of transit prompt no farther prosecution of the valuable means of support afforded by our fisheries, the convenience it would render in its present amount, would be a matter of no slight importance. The extent to which the pursuit is now carried is enormous, amounting in its produce, in the herring fishery alone, to above 450,000 barrels, and employing between 80,000 and 90,000 individuals in the catching and curing only.

In the pilchard fishery, nearly 35,000 hogsheads of fish are taken, and above 31,000 of these exported, while capital amounting to almost 250,000*l.* is continually engaged in it.

The salmon fisheries are not of the same extent or importance, but still sufficiently so to be worthy of notice. Of late years, the take has greatly fallen off—in the Tweed fishery alone, it is said, from an amount of 9,000 or 10,000 boxes a-year, to less than 4,000. Yet, notwithstanding this reduction in the amount of fish caught, the greater facilities afforded by steam-vessels for transporting it, has very materially reduced the price at which it is sold in the London markets. What then, would be the advantage gained, not only in this, but in every branch of this portion of our food supply if the considerably greater facilities afforded by railways were generally enjoyed.

Thus might the reasons be multiplied *ad infinitum*, to show the necessity of those great means of transit, derived as they readily could be, both from the increase of the business of the country on the one hand, and the impulse given to it by the production of facilities on the other; but we have not space to follow out this very interesting inquiry, and must content ourselves in the present instance, with merely giving a summary of the amounts of the chief branches of manufactures, and leave it for our readers to draw the inference of how influential they have respectively been in *obliging* the invention of railways, and the application of their principles throughout the different parts of the country.

The first instance we would adduce is that of the *woollen manufactures*, perhaps the least noticed of our great national undertakings, though in our estimation,

one of the most valuable and important. According to the best authorities, the wool yearly used in Great Britain is about 490,000 packs, or 117,600,000 lbs., which, with 30,000,000 lbs. of foreign wool yearly imported, makes the whole 147,600,000 lbs. This is considered to be worth about 7,500,600*l.*, and by the course of manufacture is tripled, to the amount of about 22,500,000*l.*, employing as many as 334,000 individuals. Of this amount, about three-fourths of the business is executed in the West Riding of Yorkshire, a district especially requiring, and offering facilities for, transit.

The *cotton trade* was introduced very much later than the woollen manufacture. The latter is said to have been in existence in this country ever since the time of the Romans, and was certainly extensively used, considering the wants of the people, shortly after the conquest by William, and indeed had a staple foundation for its virtue laid by Edward III.; but the latter is noticed by no author earlier than 1641, at which period Manchester is represented to be the chief place for the business. What peculiarities Manchester possessed for the conducting of this business it is not easy to tell, but that it must have had some beside its contiguity to the sea which divided it from Ireland, where a great portion of the yarn they wove was produced, can hardly be doubted. The neighbourhood of Liverpool could not have been of any material benefit, for its capabilities as a shipping port were hardly felt, and

certainly turned to very little account, for this splendid city which now is numbered as second in the first empire in the world, was then but the congregation of the straggling cottages of a few simple fishermen. That it must have possessed some is evident, for within less than two centuries Manchester has risen to be the largest manufacturing place in the world. Its rise is the more particularly interesting as connected with our subject, for though railways were first used for the easy conveyance of metallic ore and coals, yet the more enlarged adoption of them, an adoption that was rendering them nationally advantageous, was occasioned by the requirements of the business which was carried on there.

Down to 1773 the weft only was composed of cotton, the warp or longitudinal threads being of linen. The importation of cotton even at this early period was considerable, being as much as 4,000,000 lbs. Mr. Baines, indeed, in his history of the cotton trade, gives all the reports of the imports which the customs could imperfectly give; and he then states, that towards the latter end of the previous century, the imports of raw cotton as close upon 2,000,000 lbs. This gradually but rapidly increased, until it has attained to the enormous amount of nearly 330,000,000 lbs., employing hundreds, nay thousands, of vessels in the conveyance of the raw material and the manufactured article over every sea, and almost to every country in the world. The total value of the goods obtained from the use of

this material, is stated at 34,000,000*l.*, and employing from 1,200,000 to 1,400,000 persons in its use.

These, perhaps, are the most enormous aggregates the world has ever witnessed, and will become more and more wonderful the more the several complex operations, and the variety of interests which they comprehend are considered. How astounding the amount of intellectual energy expended in the propulsion of this extraordinary sum to its present height, is almost beyond conception. Thousands upon thousands, and tens of thousands, wait with beating hearts upon its operations for their daily bread, and gladden into joy as it grows into activity, or sink into despondency as the wheels of its progress grow slower on their axes.

In no business has the ingenuity of mechanical contrivance been carried so far, and in none has it been made so available in the expediting of processes, or the reduction or substitution of labour. It is calculated, that the labour of little short of 1,000,000 horses is supplied by machinery, in Manchester, and its neighbourhood, alone. How indispensable then was the facility of carriage to such a mass of production.

Next to the cotton manufacture, though far inferior to it in extent and importance, we may place that of *linen.* Though this branch of trade has been long known in England, the absurd restrictions which were put upon the importation of flax and hemp, for a long time prevented it from making any considerable progress, at least compared with that of other manufac-

tures. An impediment was also offered to it by the attempts to support the business of Ireland, where this trade was much followed, and also by the rapid growth of the cotton trade, articles of that fabric from their cheapness and excellence having in very many instances superseded those of the more expensive kind.

The principal places where the linen manufacture is carried on in England, are the West Riding of Yorkshire, where more than one-half of the English cloth is made, Lancashire, Durham, and Salop. The whole number of individuals employed in weaving &c., is computed at something above 16,000. But the principal portion of this business is carried on in Scotland, where it has long been considered the staple trade. At the period of the Union the quantity of cloth made was about 1,500,000 yards, and from that time it has been progressively increasing till the present period. In 1837 the total value of the linen trade in the British isles, was estimated by Mr. Maculloch at 8,000,000*l.*, and the number of individuals employed in the trade at 185,000.

The *silk manufacture* is supposed to have been introduced into England about the fourteenth century, and from that time the business materially and rapidly increased. In 1666 the number of individuals engaged in it was estimated, though, no doubt, erroneously, at 40,000; but a considerable impetus was given to the trade in 1685 by the immigration of a number of Protestants from France, who had been compelled to leave

their own country by the revocation of the edict of Nantes.

In 1719 the first mill for throwing silk erected in this country was established by Sir Thomas Lombe, at Derby, who had become acquainted with the principle of its construction in Italy. For nearly a century, however, after this period, the manufacture, though it increased considerably in amount, was conducted in a very unsatisfactory manner, and little was heard but complaint from those who were engaged in it, on account of the clandestine introduction of silks of foreign make. But the evils which had been suffered in consequence of a monopolising system of management, which prevented the open and fair competition of foreign goods with those of home make, was in 1825 removed, and since then the improvements which have been effected have been very considerable. The number of individuals now employed in the business is estimated at 30,682, and the value of the manufacture at 10,500,000*l.*

The other great important branch of national business which we deem it necessary to notice here, is the manufacture of hard-ware goods.

Metallic goods are so numerous in their kind, and require such a variety of handicraft to manufacture, that it would be useless to attempt to specify the several places where they are carried on. In real importance, it may be sufficient to say, the business is inferior to none in its influence on the welfare of the country.

Birmingham and Sheffeld, the two chief places where the manufacture is situated, have grown up through its aid to the wealth and extent of first-rate cities. The value of the goods annually produced in this branch of business is estimated at 17,000,000*l.*, and the number of individuals employed, at about 325,000.

Such is the summary of the leading manufactures of the country, though necessarily a bare one, from the space to which it is confined, yet sufficient to convey a notion of the immensity of the transactions which these totals represent; yet, even these, great as they are, will not a be true criterion to judge of the multiplicity of operations which this capital occasions, and which these individuals effect. These almost defy calculation, for the aid of machinery is so manifold and powerful, and the prices of the articles so enormously reduced from their original, and, we may say, their intrinsic value, that an enumeration alone of the numbers respectively of the several articles, would show the amount of business actually done. To give these would be next to impossible.

Yet, though we cannot thus convey so fully as we could wish an idea of the multiform and multiplied circumstances of our manufacturing and commercial business, enough is here stated to convince the minds of all of the prudence, not only of rendering to business every facility, but the imperative necessity of daily applying new means for its conduct and accomplishment.

The most absolute, and the most obvious, are rapid and easy means of transit, for, without the power of carrying goods to their several markets, or to their purchasers, it would be of little use to produce them. For a long time this was a difficulty deeply felt, and goods were accordingly often made in places little fitted for their production, and consequently, at a severe loss. But the invention and introduction of railways has remedied this great disadvantage, and not only provided facilities for the conveyance of goods from the places where they are now made, but will, in all probability, lead to the establishment of factories in those localities where the means of production are most economical and most easily procured; and thus we may naturally expect that business will not be confined merely to those branches and to those places where *natural* advantages happily exist, but we may fairly look for the whole manufacturing industry of the country being brought into profitable and active exercise.

CHAPTER II.

HISTORY OF RAILWAY MAKING.

WHEN we look around upon the many and important changes which have been wrought upon the externals of the world, and consider the mighty elements of power and knowledge which are rifely active in their existence, and extensively engaged in modifying the face of society, we are almost *compelled* to reflect upon the means by which they act, and the amount of good which they have already accomplished. However great the ridicule may be which has been thrown upon the hackneyed expression of the 'march of mind,' we cannot observe these changes, or think upon these elements, without allowing it to possess much meaning, and to represent that which is always amazing and sometimes astounding in its effects. To inquire into the principles by which it has been impelled is not our present business, we have now only to contemplate one of its results. One, it is true, but one so fraught with important consequences, and so necessary to the general advancement, as almost to be looked upon as a cause rather than an effect of national greatness

And, indeed, what is so likely to exalt a people collectively in acquirement and virtue, as that frequent, nay, almost constant attrition of mind which is invariably produced by facility of intercouse. Man is naturally gregarious; he is made for community and fellowship; and experience has proved, that wherever there is constant or continual association there, just in an equal proportion, will high, and noble, and valuable qualities prevail.

Never were these observations more strikingly illustrated than by the progress made in this country and in America during the last twenty years by the introduction of railways and steam carriages. So rapid has been the advance within that period, that we can with difficulty suppose what is the fact, that it is nearly two hundred years since the principle, thus influential, was first brought into notice and applied to the purposes of life.

The immense mineral wealth of Britain was too various in quality, and too widely spread, not to have been early observed and used; and the wonder is, that the means of transporting it with ease and expedition were not sooner devised than they were. Indeed, we may reasonably suppose that such would have been the case, had not intestine wars and the broils of religious contest for several centuries withheld the public mind from cultivating the arts of peace. Towards the commencement, however, of the seventeenth century, the increased produce of our coal and metallic mines

rendered some better means of transmitting them from the shaft of the quarry or pit an absolute necessary, and a plan was accordingly adopted for obviating the difficulty and reducing the labour thereby incurred.

The system first used was that of a wooden tramway. A series of logs of wood placed in parallel lines, and planed tolerably even, were laid down from the mouth of the pit or mine to the place where the mineral had to be delivered for shipment or deposit. These were so arranged, that the wheels of the carts or wains travelled upon them as they did in the ruts of a common road, and the only power employed to move the weights was still the same as that which had been used previous—the aid of animal strength. Prior to the introduction of this plan, the usual quantity for a horse's load was eight boles of coals, about equal to 17 cwt., but in consequence of the removal of the friction, instead of 17 cwt., it was ascertained that a horse could upon the tramway draw 42 cwt., without any additional fatigue.

The benefit thus obtained was certainly very considerable, and we may suppose that it was only owing to the comparatively slow progress of business that the discovery did not lead immediately to the introduction of some new facility. But such was not the case; for a century and a half the system remained in its pristine state, or nearly so; the improvements being such as not to be worth the name of an alteration. No doubt, the execrable state of most of the roads throughout the

kingdom was such, that the supposition of laying down wooden railways for any considerable length, would have appeared rather like the foolish dream of a moon-struck idiot, than the cool and rational conclusion of sober calculation. Cut up and mutilated in every possible way, it was alike beyond the power of the men of that day to render them so firm and durable as they have since been made, as the present rate of railway travelling was beyond their necessity. Carriages of any kind had but lately been introduced, and the rude vehicles used for the purposes of agriculture served sufficiently well for carrying home, by slow and painful efforts, the scanty produce of the ill-tilled ground. We cannot wonder then, that an invention should remain in abeyance, the nature of which rendered it valuable only for manufacturing and extensively commercial dealings. The people of England were not at that time entitled to the appellation of manufacturers in the same sense in which the term can now be applied to them, and we cannot then wonder, that they should neither appreciate a plan for the promotion of trade, nor deem it applicable for the furtherance of the comforts of domestic life, when all which they desired was produced within the range of their own homestead, or at farthest, within that of their neighbour.

But as the resources of the empire gradually developed themselves, and as the change was wrought which evinced the power that was vested in wealth, an impetus was given to all those businesses in which car-

riage was an important consideration, and the mine proprietors, especially, were ready to adopt any plan by which their business could in this respect be expedited.

About the middle of the last century iron rails began to be substituted for those of wood, and a much narrower width of bar was introduced. By this plan, however, an inconvenience was soon experienced, for it was found that the wheels were apt to run off the rails, and it therefore became necessary to provide some means to prevent this evil, and the mode that was adopted was the affixing a ledge or *flange,* as it is called, to the side of the rail.

To whom this great improvement is owing is not known. Probably several individuals are entitled to the credit of it; but the first authenticated evidence we have of its existence is, according to the report of Mr. R. Stephenson, to be found in the books of the Colebrook Dale Iron-works. A statement is there made, that rails of this description were cast for the use of one of the partners, in the year 1767; it is supposed for the purpose of trying some private experiments.

When the impetus had once been given, we find it progressing with comparative rapidity, and in 1789, a patent was taken out for an edge rail, made plain and smooth, and without any flange upon it. But, as it was necessary to have some guard against the slipping of the carriage, the flange was then transferred from the rail to the wheel. Many advantages were gained by this

alteration. There was neither the same wear of the flange, or the same strain upon the rail. Moreover, the rail was kept constantly clean, for the mud or dirt could never accumulate upon it, and thus as little impediment was offered to the progress of the wheel as could then be obtained.

Hitherto there had been no decided change in the application of the principle of railways. They were now generally adopted, and used for a variety of purposes. The system was the same as it had always been. The only difference, if such it can be called, consisted in the greater elevation of the rail above the surface of the ground. By this means, not only was the advantage of clearness from accumulating incumbrance gained, but a greater facility of traction also was the result.

Farther than this, they were unable to go. Animal power was still the only means used for rendering the rails available. Any self-moving agent not instinct with life appears not to have been so much as dreamed of, far less practically contemplated. The steam-engine had, it is true, been both discovered and applied to stational objects, and something was known of its use upon the water. But, farther than this, the powers of steam were a dead letter in the maxims of intellectual progress.

The object of railways was the easier conveyance of weighty goods, and, for the period we have named, the facility afforded by the use of the plain way of a wood

or iron rail, instead of the rough friction of a bad road, had sufficiently answered the purpose. Expedition, as well as facility, however, or rather a higher degree of facility was now required, and it was discovered that if the railway were laid upon a sufficient descent, the use of animal power might be altogether dispensed with. The plan adopted was to load the waggons, and then placing them upon the verge of the descent, their own weight carried them to the bottom. When their cargoes were delivered, horses were yoked to them, and thus they were again drawn up to the place from which they had started.

The great difficulty was so to regulate the inclination of the descent, that the transit of the waggons should not be too rapid. But this was a difficult matter, and much ingenuity was required to remedy the defect. On those descents which were sufficiently steep to carry the train with expedition to the bottom, the impetus given, especially if the carriages were heavily laden, was generally too much for their safe arrival at the bottom. One of the schemes devised was the use of a "break," by which the wheels were partially locked as they approached the more rapid portion of their descent; but this could not altogether prevent their "running amain," as it was called, that is, dashing wildly out of their proper course, and being thrown off the rails.

This plan not answering, several others were temporally adopted, but all to little or no purpose. The best of those which were tried was that of the self-acting

plain, which came into common use much about the same time that the edge rail was generally introduced. It was formed in this way. Two complete tramways were laid down instead of one, and upon each, a set of waggons was placed, connected together by a rope passing over a pully, the ends of which were attached to the two trains, so that while the loaded train was passing down, it drew the empty one up. But it was not always possible so to adjust the weights of the trains as that one should exactly balance the other, and it not unfrequently happened, that the descending train would rush down with such velocity, as to throw the ascending set out of its equilibrium, and thus throw it off the rails. Where such a liability existed, the defect was remedied by a combination of wheels and pullies, which exhausted a great portion of the power obtained by the weight of the descending train, and thus rendered the motions of both sets more equable and less violent.

This, however, did not altogether obviate the defect, and another plan was resorted to. The declination was made considerably less. It then sometimes proved insufficient, and the descending train could not obtain sufficient impetus to draw up the other. In these cases, a wheel was placed at the summit, to which a horse was attached, by whose strength the ascending train was drawn to the top.

These were all ingenious devices, and sufficiently effective, perhaps, for the object for which they were

designed, so much so indeed, as to render any other unnecessary for that purpose. But they could only be applied to short distances, and those only for which the length of a traction rope could be used, and were wholly inefficient for any others. Here, then, a limit was put to the exertions of those who were desirous of rendering science subservient to utility; and without the discovery of the native power of steam, or some other similar agent, the benefit must have ended. Steam, however, supplied the grand requisition, and, when once brought into effective operation, soon led to the adoption of more enlarged and powerful methods of utility, in the way which the discovery of the principle of the railroad had laid open. The advance of mechanical knowledge, together with a more correct acquaintance with the chemistry of steam, soon developed the innumerable methods by which, as a motive power, it could be applied. Prejudice certainly tended much to impede its application, but the successful result of experiment soon set such feeble opposition aside.

If we look through the history of the world, and consider those several expedients by which the great impulses have been given to the human mind, and the consequent condition of the human race, we cannot fail being struck by the singularity and apparent insignificance of the means by which any of these great changes have been effected.

The simple and almost foolish experiments of a few half informed and obscure individuals, in a place almost

as little known as its inhabitants, have created a power which is felt to the utmost corners of the earth; which by the influence of its might has rocked the thrones of dynasties established on the prejudice, the reverence, and the fears of a thousand generations; which has produced that moral equality before men which ever existed in the sight of God; which has lifted the humble from the dust, to the level of the highest, the noblest, the most honoured of the land; and abased the proud from the false dignity of the station they disgraced to the depth of the meanest, the lowest, and the most despised of the wretches that crawl the surface of the earth; which has dispelled by its instrumental agency of Almighty love the darkness of meridian night that held the sons of men enthralled before the idols of a base and degrading superstition—that has lifted virtue to the fulness of its native stature, and enabled it to combat unaided and alone, as men might think, with all the array of temporal authority and satanic malice; that has wrought out the charter of man's glory and honour which revelation had prescribed, and engraved them in characters of indelible endurance on the tablet of every heart, and on the frontlet of every brow where purity, and holiness and affection, are esteemed, and where the marks of divine origin are traced, retained, and borne—that has burst assunder once and for ever the green withes that bound the strong man escaping the trammels of his wily enemies, realising by antepast the sublime scene of apocalyptic prophecy, in which the

angel, whose head shall reach to heaven, shall stan with one foot on land, one on sea—has elevated i an unseen hand the banner of supreme good will, an proclaimed in a voice that shakes the firmament by i sound "Error, thy reign is ended."

So steam, though inferior to the invention of th press in its influence on the welfare of mankind, ha been all but supreme in that which it has been destine to use; an agent that, from its subtilty and tenacit few would, when uninformed, have suspected of th power which is inherent in it, has gone far to realise th fabulous supposition which the temerity of Eastern ima gination has supposed, that time and distance could b annihilated. Already has it brought the ends of th world together; already has it made time almost creature of our will; already has it shown powers wit which human intellect is as yet unable to grapple already has it exposed the bosom of the dark earth, fron the substance of which the secret of its power is ob tained, and man's ingenuity is now at fault to put limitation to the extent and value of its use.

At first it was suspected—it crept—it was thought i might be made available. The ill-informed and heavy but ardent and persevering, mind of the amiable Mar quis of Worcester, endeavoured in vain to render i efficient for mechanical movement. But minds, mucl better acquainted with the nature of matter than his were at work upon it; men engaged in the practica affairs of life, whose bread depended, or rather began tc

depend, upon their economical production of the comforts of life, found the want of some assistant in their daily operations that no lever which human power could move was ably to supply. Truly is there a fund of noble wisdom wrapped up in the conceits and experience of our unwisely despised ancestors, and truly may we say, their sage though homely language, that necessity is the mother of invention. The power obtained by falling water had been sufficient to satisfy the requirements of all operations which were to be carried on above ground, but there were no streams of sufficient magnitude and permanency to secure their constant utility in our mining districts. There the land is barren, the soil ungenial, and the substratum a continuance of rocky stratifications. In such cases *steam* came in as an efficient and invaluable agent.

It is surprising that the first application of steam power was not to some manufacturing process, for there appears a daring of thought in putting it to the use to which it was originally turned, and its being so applied evidences a correctness of judgment and a knowledge of things which we should not have expected from men of such comparatively confined experience. The first application of it appears to have been to draw the water from the mines of Cornwall, and for shallow depths, it was found a very efficient ally.

The merit of its invention appears to be justly ascribed to the Marquis of Worcester, who published his "Century of Inventions" in the year 1663. This was

a work descriptive of one hundred contrivances, which he conceived would be of material service to the public, and he therein claims great credit, and calls largely upon the support of the country, for the promotion of his schemes. His notice of the Steam Engine is the sixty-eighth of these hundred plans. The words he uses in giving an account of it are as follows:—" This admirable method of raising water by the force of fire has no bounds, if the vessels be strong enough; for I have taken a cannon, and having filled it three-fourths full of water, and shut its muzzle and touchhole, and exposed it to the fire for twenty-four hours, it burst with a great explosion. Having afterwards discovered a method of fortifying vessels internally, and combining them in such a way that they filled and acted alternately, I have made the water spout in an uninterrupted stream forty feet high, and from vessels of rarified water raised forty of cold water. The person who conducted the operation had nothing to do but to turn two cocks; so that one vessel of water being consumed another begins to force, and then fill itself with cold water; and so on in succession."

This is as closely an approximating description of the operation of steam in its formation in the present day, as with the describer's imperfect knowledge, could well have been given, and the germ of the invention is sufficiently apparent.

Shortly after this time another individual, whose at-

tention had been turned to the same subject, succeeded in bringing the matter to a much more practical use. This was a Captain Savary, by whom the fact of the expansibility of steam had been observed, as also that of the speedy reconversion of steam into water by the agency of cold. It was found when water had been raised to such a degree of heat as to become vapourised, that the introduction of even a few drops which were cold immediately abstracted a great portion of the heat of the steam, and reconverted it into water. He availed himself of the induction which this circumstance offered, and constructed a machine for the purpose of raising water. The tin mines of Cornwall offered the first and most needy opportunity for the use of his invention, and accordingly several machines upon his plan were erected. In 1692 he secured the protection of a royal patent for his productions, and in 1696 published an account of his scheme and machines in a work entitled "*The Miner's Friend.*"

Endeavours were made to rob Savary of the credit of his discovery, and it was stated, that he was arrogantly claiming the merit of that which was, in fact, the work of another; and, it was even said, that he had seen and bought up every copy of the Marquis of Worcester's book, and burnt them, in order to secure the fame of the invention of steam to himself. This, however, appears to be a groundless calumny. Savary had much opposition to contend with, and the discussions which arose

out of it indicate him to have been well acquainted with the principle of steam power.

Our versatile neighbours, the French, have also endeavoured, with a good faith and candour not at all uncommon with them, in their appropriations of the credit due to British genius, to ascribe all the merit of the application of Savary's discovery to themselves. A countryman of theirs, Dr. Papin, was about that time over in England, and became a member of the Royal Society. He was one who, apparently, with a general but imperfect knowledge of the laws of mechanical forces, set up for a great mechanician and philosopher, and some of his plans, had they but a little more good sense in their constitution, would seem to be plausible enough. But in this instance he was notoriously out, and utterly failed in all his attempts. His claims to the invention are now pretty well understood, and appreciated accordingly.

The machine of Savary was soon found insufficient for its object. Useful, certainly it was in a very high degree, but its power was decidedly too limited for any extensive work. For a height of thirty to thirty-five feet, it served very well, but beyond that, it was felt to be quite inefficient. Greater power could certainly be obtained, but it was only by the use of a pressure which few cylinders were competent to sustain, and the fracture of the metal of which they were composed was far from being an unusual occurrence. Indeed, almost every experiment produced this unfortunate result.

Another great disadvantage was the waste which accrued both of steam and fuel. The great radiation of the cylinder acted too forcibly, and condensed the steam so rapidly—causing the consumption of a most extravagant quantity of fuel—as to nullify the generation of the vapour. No efforts of Captain Savary could sufficiently remedy this defect, and his machines were, consequently, found to be both expensive and inefficient.

But there was also another mind actively engaged in the prosecution of this subject, that of the sagacious and scientific Hook. Few men had accomplished more for the progress of chemical science in his day than Dr. Hook, and, though he does not appear to have effected anything directly for the furtherance of the perfecting of the steam engine, and is not to be looked up to as a mechanical contriver, yet, he did much, doubtless, in promoting the success of the contrivances of others.

As we have already stated, the first object to which the power of steam was extensively applied was the emptying of water from the mines of Cornwall. Its utility for this purpose was perceived immediately on its successful control being made known, and excited much curiosity and discussion in that part of the country. Among others by whom it was investigated were an iron dealer, or blacksmith, of the name of Newcomen, and a Mr. Crawley, of Dartmouth, in Devon, both engaged in the tin trade. The former, especially, was a man of clear thought and ingenious mind. He

was well known as the friend of Dr. Hook, and it is little to be doubted, but that he had heard something of this new power in his converse with that gentleman.

Newcomen perceived that between the waste of one expansive throe and the generation of the next, there was a period during which the piston descended, and there was a loss of force. Moreover, Savary had been obliged to make his piston descend by the aid of steam. This defect Newcomen remedied, by allowing the weight of the atmosphere to do its own work. The cylinder being exhausted of air, and a vacuum created, the piston would of course naturally fall, and he calculated that the weight of the atmosphere would, if the engine were judiciously placed, counterbalance the weight of the water to be raised.

The steam engine had obtained the fullest power with which Newcomen could invest it, and in his specifications, and in the engines which he erected in 1712 and afterwards, he deemed it nearly complete. Nor was he alone in his supposition, for his engines continued to gain credit, and were for many years much esteemed.

These were certainly great improvements, but, yet so much depended upon the precise observance of the movements of the engine, that they were subject to a variety of accidents. If the cocks, by which the boiler and the cylinder communicated, were not opened or shut at the proper moment, the bottom of the cylinder was burst out, or the piston was drawn out of its

place. Much safety and benefit, however, was obtained in the course of a few years, by the ingenuity of Beighton, who very greatly simplified all the movements of the engine.

Thus, for a long period, did the form of the steam engine continue, and its principle remain unchanged. No alteration, indeed, of any importance took place, unless we consider the change of the position of the boiler such. Hitherto it had been always placed under the cylinder, but was removed about this period from the bottom to the side of that portion of the engine; and then for a period of fifty years, this life-like machine continued to act with its comparative feeble and intermittent motion, without any attempt being made to improve its form, or increase its power.

The first endeavour, with this view, made after the alterations of Beighton, was that of Mr. Kean Fitzgerald, who published a statement of his principle in the Philosophical Transactions. He endeavoured to change the reciprocating into a rotatory motion, by attaching a fly, or great beam, to the piston rod, or by the use of a huge crank connected with the piston by a coupling bar. Either of these he so adjusted, that a degree of momentum was acquired in the descending stroke, sufficient to carry the fly, or crank, on its rise, above the zenith of its ascent, and by this means, he partly accomplished his object.

One great obstacle, however, to the use of the steam engine, yet remained. The consumption of fuel was so

immense, and the expense consequently so great, that in many cases it was utterly impossible to employ its aid in any but very extensive works. It is stated, that as much as 3,400 London chaldrons of coals were consumed in a year by an engine of only six feet diameter.

At length, Dr. Black's beautiful discovery of the existence of latent heat led the way to an inquiry into the amount of heat expended in boiling water, and also, into the quantity of steam which it produced.

One day Watt, who was at the time a manufacturer at Glasgow, was amusing himself with repairing the model of a steam engine belonging to the university, and being acquainted with his friend Black's recent discovery, ascertained that the quantity of steam generated from a certain quantity of water was much more than was necessary to produce the motion of the engine. He found that if a few drops of water be put into an empty vessel, and fire be applied either underneath it or to its sides, and an aperture be made at the top, the steam will pour out of it like a torrent. He discovered also, that as much as three or four times the quantity of steam that was necessary to work the engine was lost in warming the cylinder, and the idea struck him, that the steam might be condensed at a little distance from the cylinder. He had, however, previously tried to accomplish the saving of fuel and of steam by the use of wooden cylinders. This in a great degree saved the radiation, but the plan had great disadvan-

tages, and he next cased the cylinder with a lining of sashes between the barrel and the wood, by which it was covered. By this means a disadvantage was felt in the inside of the cylinder being hardly ever brought below the boiling point. He, therefore, adopted another plan. He had a globular vessel immersed in cold water and communicating with the boiler by a pipe one inch in diameter, and thirty inches long, having a stop cock. In the first experiment, the cylinder which was only of tin plate was crushed to pieces. He then had a cylinder made of brass with the necessary orifices and capable of sustaining the pressure to which it would be subjected, and he then had the pleasure of procuring an unintermitted supply of steam sufficient to produce a continuous rotatory motion.

The extent of the advantage thus obtained is best ascertained by the comparison with the amount of animal power which it displaced. An engine having a cylinder of thirty-one inches diameter, and making seventeen double strokes in a minute, did the work of forty horses, and from going by night as well as day accomplished a duty equal to the powers of three relays of horses, or as many as one hundred and twenty.

Hitherto the power of steam had only been applied in rectilinear motion, and most chiefly to the drawing of water; but the complete attainment of the rotatory power gave greater facility to its use; and in 1759.*

* The idea is said to have been first thrown out by Dr. Robinson, then a student at Glasgow.

Watt attempted to apply it to one of the most important uses to which it has ever been adapted, that with which we have more especially to do, the moving of carriages. It is singular that this attempt was made about the same time as *iron* rails began to be introduced on the tramways at our collieries and mines.

In the first introduction of steam as a motive power, that best and most able mode of its action, its effect by expansion was that most frequently used. It was, however, found exceedingly difficult in that way to manage, and after several futile attempts to render it effective the plan was abandoned, and for nearly half a century condensation was used in the application of steam. Nothing should more excite surprise than the nature of the obstacles by which scientific men have been prevented from carrying a design out to a successful result; indeed, they are quite as surprising as the discoveries themselves, if not much more so. Posterity will hardly credit the fact that the great hindrance which prevented one of the most palpable applications of steam, that of propelling locomotive carriages, was a bug-bear of the imagination, an *ignis fatuus* of supposition which one would have supposed a school-boy could have seen through and exposed. Long before any thing like an approach was made to using steam on land, the uncertain agent of water had been put into requisition. In 1789, Mr. Symmington propelled a boat on the Forth and Clyde Canal, under the inspection of the American engineer, Mr. Finlay, and

again in 1802 and 1803 he had constructed, and was working one of greater power and perfection under the auspices of Mr. Dundas, and within a very few years afterwards ships of the first order were ploughing the waves of almost every sea upon the globe.

Thus it was upon the water, while not a single attempt with any probability of success was made upon land until the year 1804, when a patent was obtained for a locomotive steam engine to work upon a railroad, which was invented by Mr. Trevithick, and two years afterwards we find it in operation at that nursery of mechanical art and seat of manufacturing industry and enterprise, Merthyr Tydvil, in South Wales.

This drew attention again to the application of the expansive principle, which has since been so advantageously and beneficially carried out to its present general extent. The principle of the generation of steam was pretty well understood, and its application as a motive power had been well tested in its use in steam vessels, and every day was bringing to light some new fact of its energy and manageability. Yet notwithstanding the great advance of physical science, it would almost seem that no great originality of genius had been for some years displayed, for the use of steam power in locomotive machines was stopped almost *in limine* by the starting of a difficulty of imaginary existence, the supposed extent of which may be estimated by the devices adopted for obviating it.

The great object in the first institution of railways

was the avoidance of friction, and in the application of animal power, this object was very effectually attained. It was observed, that friction, which so greatly retarded the motion of vehicles, was caused by the adhesion of the tire of the wheels, or other surface, which touched the ground during progress, and it was judged, that in proportion as this adhesion was reduced, would be the rapidity hence obtained. But it was also perceived, that a certain degree of adhesion was necessary to cause the wheels to turn round upon their axes. The amount of this adhesion, however, was not correctly known at the period when the attempt was made to introduce locomotive machines. All the information that was possessed upon the subject was vague and general, and, as is usual when such is the case, it led to erroneous conclusions. The engines that were constructed proved inefficient, and all the defects in their performance were ascribed to some defect in the adhesiveness of the machine. That adhesion does exist, and generally in a degree sufficient to produce progressive motion, is now well known; but, an impression prevailed at that time, that it was altogether insufficient, and various contrivances were used to obviate the supposed defect.

Better information convinced the inquirers, that the adhesion of a vehicle is just in proportion to the pressure it bears, or, in other terms, to the weight that rests upon the sub-surface. It was also discovered that this adhesion was regulated by certain laws, and that it was in proportion to the extent of the surfaces in contact,

as well as the weight of the superior moving body, and that, therefore, a carriage on two wheels will have only one half the adhesion of one upon four. Nor only so, for as might naturally be supposed, the state of the contracting surfaces was found to have considerable influence. Two surfaces which were particularly smooth were found to have less hold upon each other, than two which were rough. The latter were found to have greater tenacity of *gripe*. The protruding points on the upper surface could render the opposing hollows of the lower face available in its propulsion forward.

It was found that the amount of power necessary to overcome the adhesion of the wheels to the rails was that which was sufficient to drag the carriage forward upon them, when the wheels were *fixed* at the axles, and when the movement was minus the rolling motion, and it was ascertained from experiments, that the power thus exercised was about one-eightieth the weight of the machine on each wheel, or if the machine were a two wheeled carriage, about one-fortieth, or if it were a four wheeled carriage, about one-twentieth, or a fifth of the whole, in an uniform or fair state of the rails. Thus, on a machine weighing five tons, if it had four wheels, the adhesion would be equal to about five hundred weight, or if it were a two wheeled carriage, it would be 2½ cwt. But absence of sufficient data upon the subject led to much confused supposition respecting it.

Blenkinsop invented what, under the circumstances, was a sufficiently ingenious process, but which, if adopted, would have been both expensive and inefficient for long distances. He formed a rack, reaching the whole distance of the rail, and had the wheels made with corresponding teeth to catch hold of and fit into the racks in their progress, and thus they worked their way. In 1811, he made it the subject of a patent.

Another plan was that of Messrs. W. and E. Chapman, who adopted a chain fixed along the centre of the railway which was grasped by a grooved wheel and roller at each stroke of the engine. This was in effect much the same scheme as Blinkinsop's, and attained the same operation by a similar principle, and not very different means.

Mr. Brunton, a man of considerable ability, adopted another scheme more complicated, but upon the whole, more likely to attain its object than the other two. He used two moveable iron legs, jointed, and terminating in a claw. These were placed behind the engine, and were connected with, and acted upon by the piston. As it moved at every stroke, it impelled the legs, which fixed themselves in the ground, and thus drove the engine forward.

These plans were doubtless all ingenious, and if the supposition respecting adhesion had been right for which they were constructed, would have been admirable exemplifications of the laws of mechanics; but the premises were erroneous, and the conclusions

consequently false. Instead of obviating defects, these contrivances absolutely created them. They all intended to create friction, and consequently loss of power, and all the evils were increased just in proportion as these plans were deemed to be successful. These having all failed, the notion of a locomotive engine was almost altogether given up, and a new plan was adopted for the carriage of goods upon railways. The old scheme of passing the carriages which was used prior to the introduction of steam power was again resorted to, but with this advantage, that formerly a descent or inclination had been absolutely necessary to the operation; but now a plane surface without inclination served the purpose. The use of a stationary steam engine supplied the means of propulsion, and a rope having its ends attached respectively to the receding trains, or an endless chain attached to one train sufficed to communicate the motion. In some few instances we believe this plan was put into actual operation, and for limited service acted very well.

At length in 1813, a new light was thrown upon the subject by the discovery of Mr. Blackett, of Wylam Colliery, that the adhesive power alone was sufficient to produce motion in an engine with loaded carriages either upon a plane surface or even where there was a slight ascent, and he put the principle to test by introducing a locomotive engine on his railroad, which worked by the adhesion alone of the wheels upon the rails. This

altogether changed the state of things. New views were opened, and the direction of mind was uniformly given towards the promotion of improvement in locomotive carriages. Great advances in the mode of construction were the natural result, and long before the opening of the first railway of any extent, they had attained a degree of perfection alike honourable to their inventors, and useful to the country. So great, indeed, was the benefit derived, that an engine of moderate capability was found sufficient for the traction of a load that would have required the exertions of a hundred horses.

About the period when these improvements were taking place, and shortly prior, indeed, to the introduction of fixed engines, a considerable improvement had been effected in the manufacture of railroads. Economy, and the facility of making them, had induced the almost universal use of cast iron for the rails, but though cheaper in the first cost they were soon worn out, were subject to easy fracture from the strains of the engine, and were very sensibly and greatly affected by the influences of the weather. True it is, that even to the present day, much uncertainty prevails as to the respective excellencies of wrought and cast iron for the purpose, but if we may judge from the use of them, the former is likely in the end to be generally if it be not universally adopted.

No less important has been the discussion respecting the sleepers or blocks on which the rails rest for

support. Stone, wood, and concrete have had their respective approvers, and the question is even yet hardly settled as to which is best. The chief difficulty has arisen from the circumstance, that warmth and cold have a great influence in the expansion and contraction of metal. Nor did this matter alone affect the substance of which the rail was composed, but also the way in which it was fastened to its supports. If stone were used for the sleepers, the expansion of the metal was found to split the blocks. Wood in some degree obviated this defect by its elasticity, but it was not so firm to rest upon as stone. Concrete offered greater durability, and possessed the quality of firmness in a high degree, but it altogether resisted the expansion of the metal, and though the blocks themselves were not split the fractures of the rails very often ensued. Each of these plans has been adopted in different parts of the kingdom, and the question remains undecided to the present day. The nearest approach to a complete obviation of all the difficulties has been by the plan adopted by the Directors of the Birmingham Railway Company. Prior to the casting and laying down their rails, they offered a premium of considerable amount for the best plan of a rail and fixing it upon the sleepers, which was adjudged to Mr. Barlowe, Esq., the results of whose experiments were published in 1835, by Mr. Fellowes, of Ludgate-hill, under the title of "Experiments on the transverse strength and other properties of malleable iron."

His plan was to form a rail of malleable iron, increasing in size from the surface to the base, and made uniform in width throughout all its length. His mode of fixing was to fasten one end firmly down to the sleeper, but to allow a little play at the other; thus giving a little room for the expansion of the metal as also for the riving of a train. It would seem to have been successful, and that both much annoyance and expense have been saved to the Company by the adoption of his plan.

In the year 1820, or within a season or two after it, every concern in the country of any magnitude which had to convey its goods to any warehouse or port within a short distance, had made a railway of its own. But, for the formation of ways of a greater extent than a very few miles, difficulties of a most formidable character had to be overcome. Heights had to be levelled, hills to be excavated, rocks to be bored through, the vallies raised, and literally a highway to be made of equal elevation through mountain, dale, and stream. All the obstacles which the natural inequalities of the surface of the country presented were to be obviated, and, indeed, to be rendered available for the general service of the design. Never, perhaps, was scientific skill more eminently displayed, than in the engineering details of our principal railways. Inquiry was prompted by the necessity of the case, and though in the earlier statements laid down for the execution of works, the theoretic expense of their

conclusion was frequently at fault, no design was ever yet taken in hand for execution, that we are aware of, which was not in the end completed, and some of the most splendid achievements that the human intellect has ever accomplished have been effected in this way. Perhaps if the annals of science were to be searched for instances of skilful and successful enterprise, nothing would be found to equal the establishment of a firm and safe road for such immense weights as hourly pass over it across the quaking and yielding bog of Chat Moss.

We have thus attended exclusively to the progress of railway making in England, because it has here been conducted with most perseverance through all its stages to its present state of completeness; but the matter had also occupied much attention among the British descendants on other side of the Atlantic, as well as upon the continent of Europe.

The inhabitants of the United States have ever been distinguished for their enterprise, and in this respect they have not been a whit behind their British competitors, indeed, for extent of mileage, they have been far before us; for there the principle was seized upon with avidity. The distance of places from each other in the immense tract which they occupied, rendered a rapid means of transit peculiarly desirable, while the immense plains every where to be met with which intervened between their cities, offered the opportunity for railway communication while the endless forests of

timber, growing, perhaps, since the era of the deluge, supplied the materials for their speedy and cheap construction, and railways have accordingly progressed more rapidly, and to a greater extent, in the United States of America than any where else, and are rapidly becoming almost the sole means of passage within that territory.

In Germany also and in the flat country of the Netherlands, attention was easily and greatly excited to the subject, and some of their savans indeed, with a modesty to which we have before had occasion to allude, have laid claim to the credit of constructing the first railway that ever was instituted. They say that the first railway was one formed in the mountainous district of the Hartz, and that the principle was brought to England in the year 1676, by some miners who were imported in order to instruct Englishmen in the best mode of following their art. But the story has several suspicious circumstances attached to it, and obtains but little credit.

To England the merit appears undoubtedly due of inventing and perfecting this novel and excellent system of communication and of transit, and when on the 17th of September, 1825, the Stockton and Darlington Railway was opened for general operations, and for the public service, the triumph of the plan was complete.

CHAPTER III.

THE ACCESSARIES AND CONSTITUENTS OF A RAILWAY.

EXPERIENCE evinced soon after their first establishment, that in the accomplishment of railways of magnitude, considerable skill was requisite to render the work permanent and useful. The attention which had been drawn to the subject led men of science, both practical and theoretic, among others, to consider what was necessary in order to make a railway of any considerable length, and so well had the matter been considered, that when the time arrived for carrying an extensive design into effect, the art of civil engineering was found fully competent to the execution of its novel tasks.

These were neither few nor slight, for in a country so variable in its surface as England, almost every contingency that could be imagined had to be provided against. Did we possess the almost uninterrupted flats by which Holland and Belgium are distinguished, or those extensive plains which form the prairies of the American continent, common powers would have been adequate to the fulfilment of every duty which the necessity of the circumstances created; but such is

not the case. Within the compass of a district barely equal to a fourth of the extent of one of the trans-atlantic plains almost every variety of surface is to be met with. Hills have to be levelled, vallies raised, rivers to be crossed, waters to be turned, marshes to be made firm, tunnels to be formed, excavations dug, and every accident provided against that could either affect the labour of the machinery, increase the wear of the engines or the rails, or interfere with the safety of the way.

To effect such a variety of important purposes much skill of course, and many expedients were requisite. These have been supplied with an abundance and sufficiency which the comparatively short period that has elapsed since the subject of railway making became a prominent matter of scientific consideration would not have induced us to expect. The best mode of doing things has not, perhaps, in many cases yet been discovered, but much has been already attained, and we feel that we should be doing an injustice both to the subject and the reader, if we did not bring the several components of a railway, and an account of its accessaries into our present disquisition. They are many of them curious, and most of them interesting, and we will, therefore, take them in what appears to us the natural order of progression, and continue the description through what we may imagine the changes of the face of the country.

The commencement of proceedings is technically

termed *breaking ground*, and it is well to select the spot for the purpose judiciously, in order that the railway or some portion of it, may be rendered available for utility or profit, as speedily as possible.

Having, then, fixed upon the station, we will presume that for a short distance we have an uninterrupted level, with a fine burst of campaign beyond it, varied by all the rich constituents of stream, and dale, and hill; the beautiful country lying like a garden before us, separated into its plots of pasture, or meadow, or arable land by its well-trimmed and thick grown boundaries of hawthorn hedge, redolent with perfume, and flinging abroad beneath the bright full sun the fragrant odours of the pink, and white, and variegated May flowers, dancing with gladness in the splendour of the morning beams, while the spring-leaved twigs are throwing their graceful spiry arms about joyfully in the breeze. Above them, in the full dignity of their noble forms, the lordlings of the dale rear their leafy crests. The oak, the elm, and the ash, with each its beautiful and peculiar foliage glancing in the sunlight, with their shadows leaping and playing with intermingling shade on the dark green grass beneath. Far in the bounding horizon the blue zenith of the sky above has softened and faded, and now changes with the tenuous vapour which the day-god has drawn forth, till it has thrown a misty veil over the line where the earth and air are mixed in one undistinguishable haze of light.

Midway in the landscape the winding river flows freshly on, its surface gleaming like a burnished mirror, until far before us towards the left its stream is lost behind a huge mound that swells boldly against the sky—a full round bulging hill, with here a thorn, and there an elm, and there again an ash, the size and kinds of which are lost to the distant sight.

We stand upon the declining side of our vantage ground, and looking through the glad valley beneath our feet with all its varieties of indentation, survey a long and substantial work that stretches level as a die, and true as an arrow's flight till it is lost, and seems to vanish in the side of the far-off hill. It is an *embankment* that our talented engineer has raised by the perseverance of his magic skill, and thus has obviated the necessity which would otherwise have existed for two expensive engines, to raise that moving monster of a thousand tons, which, with its herald pouring forth a feathery stream of tinted cloud, glowing bluely by its ethereal thinness on the air, hastes, like the meteor creature of another world, to deposit its burthen at the appointed place.

Along the summit of the mound on which it is journeying, the most perfect level is sustained, while its sides, gradually receding until their base is twice the breadth of the top, present two steeply inclined planes, on which the verdure has already sown its beauty. Such is an embankment.

Wherever opportunities allow, works of this kind are formed from the excavations of the higher portions of the railway course. When, however, these excavations are remote from the place of the embankment, what is called *side cutting* is resorted to; that is, the land on either side is dug out to provide materials for the mound. By so doing the expense of leading is reduced, though that incurred for the purchase of land is of course proportionably increased.

The greatest quantity that can be teamed over an embankment in one year, is allowed by experienced engineers, as stated by Mr. Whishaw, to be 230,000 to 250,000 cubic yards. By augmenting the slopes an immense increase in the bulk is occasioned. An embankment thirty feet high and sixty-six feet in length, thirty-three feet in width at the top, with slopes of $\frac{3}{4}$ to 1, contains 4,070 cubic yards, and with slopes of 1 to 1 6,820 cubic yards. The broad green embankment on the Liverpool and Manchester Railway is not quite three miles in length, with a breadth of 60 to 135 feet and an average height, and about thirty feet in height; the whole quantity of the material is 550,000 cubic yards. Some of the highest embankments that have yet been formed are on the Clarence Railway.

Having passed over the plane of easy transit, we are brought to the mouth of a huge, dark and cavern like entrance. The passage to which it leads is faced with well cemented masonry. Before us lies the long dark passage, with just a gleam of light like a disc

of white in a dark place; along the ponderous train thunders in its course, and sight and hearing are almost lost in the darkness and the din; and this is a *Tunnel.*

Few things in the art of railway making have more tried the skill of the engineer than the construction of well made tunnels. They are formed either by an horizontal perforation of a hill or by sinking vertical shafts after the form of a well, and then bringing them into connection. The latter is the most frequent method.

The tunnels on the Manchester and Liverpool Railway are three. The first from Wapping to Edgehill, is 2,200 yards long, twenty-two feet in width, and sixteen feet high. The walls are five feet high, and from them a semicircular arch arises, formed of brick, except where the natural rock, as it does for a portion of the way, constitutes a roof sufficiently firm. The small passenger tunnel from Edgehill to the station in Crown-street, is 290 yards in length, fifteen feet wide, and twelve high, and the new tunnel is twenty-five feet wide, nineteen high, and about a mile in length.

On the Birmingham Railway there are several tunnels amounting in length to a little more than three and a half miles, the principal of those are Primrose Hill, Kensall Green, Watford, Weedon, Kilsby, and Birkswell.

The first of these is 1,250 yards in length, twenty-two feet high, and twenty-two feet wide. The vertical shafts left open for ventilation are five in number, and

about nine feet clear in diameter. The brickwork is eighteen inches, or one and a half bricks thick, and built for the most part in cement. A horse gin was set up at the top of each of these shafts for the purpose of lowering brick and other materials, and raising the clay excavated. The Kilsby Tunnel was the most difficult af any to execute, on account of the strata through which it was carried, which was for a certain extent running sand; one of the most troublesome of all the strata in which tunnelling is executed. Loose materials of this kind are also found the most difficult to manage in mining operations, of which tunneling indeed constitutes a main part. The Kilsby Tunnel is about 2,200 yards in length.

On the Newcastle and Carlisle Railway, which is sixty miles in length, there is but one short tunnel. And on the Leeds and Selby Railway, on which an immense number of passengers are carried, there is one tunnel 2,100 feet in length, seventeen feet high, and twenty-two feet wide. In it there are three shafts left open for ventilation. The entrance to the tunnel on the Whitby and Pickering Railway is in the castellated style of architecture, and is a very striking feature in the romantic scenery amid which it is placed. The tunnel itself is 130 yards in length, ten feet wide, and fourteen feet high. The side walls are upright for nine feet, and support an arch of eighteen inch brickwork. The tunnel in the Leicester and Swannington Railway is about a mile in length, ten feet eight inche-

wide at the ground, and eleven feet five inches at the springers of a semicircular arch. There are eight shafts left for ventilation. The usual speed at passing through this tunnel is about fourteen miles an hour.

These details will give a tolerable idea of the extent to which this species of work is carried. In a country so variable in its surface as England, no railway of any extent can be constructed without a tunnel, unless extremely and unprofitably circuitous routes were to be taken. For a long time considerable prejudice existed against them under the supposition that they were unhealthy, and many endeavours were made to obviate the necessity for them, but we believe this prejudice was found to be groundless, and the idea is now almost altogether exploded by the reports of several eminent medical gentlemen who were employed to ascertain the fact whether they were so or not. Drs. Paris and Watson, with three other gentlemen, made an experiment in the tunnel of Primrose Hill on the London and Birmingham Railway before it was completed, and when in consequence of one end being closed, the circulation of air was not nearly so free as it afterwards became. "We found," they say, "the atmosphere dry, and of an agreeable temperature, and free from smell; the lamps of the carriages were lighted, and in our transit inwards and back again to the mouth of the tunnel, the sensation experienced was precisely that of travelling in a coach by night between the walls of a narrow street. The noise did not prevent easy conver-

sation, nor appear to be much greater in the tunnel than in the open air." The reports of Drs. Davy and Rothman, and also Dr. Williamson, senior Physician of the Leeds General Infirmary, as to the Leeds and Selby tunnel, were much to the same effect. The fact is thus decidedly established, that there is no deleterious influence to be feared, though we believe that few individuals who have ever passed through a tunnel but will hesitate to subscribe to the representation of this very highly respectable authority respecting the noise and inconvenience invariably experienced.

But, again, we see the light increase, and in an instant the broadness of daylight gleams once more upon us. The glad sunshine descends not into the ravine, for two slanting walls are reared on either side of us. Upon their upper edges we can see the green blades wave in the golden sunlight, and the bright air and the blue sky are gleaming above; in a variety of places, gravel and broken granite are spread, sometimes mixed, sometimes separate, giving to the sides of the *excavation* an appearance of firmness, while, at the same time, the loose sand or mould is prevented from crumbling down. About half way up, a sort of level stage or pathway is formed which runs very nearly the whole length. The hill here is not so lofty, and a change in the strata has rendered it advisable to make the rest of the way through it an excavation instead of a tunnel. The gravel and granite which we see are termed *ballasting*, and serve the purpose which is,

however, sometimes better, and more pleasingly effected by other means as in some places on the London and Southampton Railway, by the planting of trees and shrubs, and the sowing of grass seeds. The pathway which we see is termed a *bench*, and it is used whenever a change is required from one slope to another, on account of the difference of strata. Tile drains are frequently introduced in these benches with great advantage, and preventing the formation of gullies at the bottom by the descent of the surface water.

Excavations are sometimes works of considerable magnitude. The excavation of Olive Mount, on the Manchester and Liverpool Railway, was effected by the removal of 480,000 cubic yards of sandstone rock. The sides of it are perpendicular.

Onward, and onward still, the monster spurns in its fiery course. Again, the fair face of nature with all her calm and witching beauty lies in sunny cheerfulness around us. A little to the right an ancient turnpike crosses obliquely the path of our railway. It seems broken and yet continued, for it runs its thread-like course again on the other side until it is lost in the wood on our left. We come near it—it is gone—we have passed. A momentary glance enabled us to perceive that it sunk and sunk gradually until it passed beneath an arch which supports our more level passage.

Care is necessary so to keep these slopes of ascent and descent upon a right inclination. Mr. Walker, in his examination on Railway Bills before the Committee

of the House of Commons, stated his opinion, that the slope for turnpike roads in passing either over or under a railway, should not be more than one foot of rise in thirty feet of length on turnpike roads, one in twenty in public highways, and one in sixteen in occupation roads; and provisions are accordingly inserted in all railway bills to secure that rate. Mr. Whishaw, in his excellent " Analysis of Railways," gives for the benefit of his readers, a statement of the rises of some well known places in London, which are as follows:

The greatest rise of Holborn Hill is	1 in 14¾
The average rise.	1 in 24
The greatest rise in Skinner-street.....	1 in 18
The average rise.	1 in 32
The greatest rise of Blackfriar's Bridge	1 in 16¼
——— of St. James's-street.........	1 in 23
——— London Bridge, Surrey Side	1 in 27
——— Upper part of City Road...	1 in 40

On each side of the outer rail we observe there is a space left to the edge of the embarkment. This is called the *side space*, and is left both for convenience and safety.

The side space of the Greenwich, and of the Canterbury and Whitstable Railway, is about three feet, of the Clarence Railway five feet, and of the Dublin and Kingston Railway nineteen feet.

When there are two pair of rails on a way, as is the case on all large ways, one for a proceeding, and another for the returning train, the space between each line of rails is called the intermediate space. On the Liverpool and Manchester Railway it is about five feet

eight inches; on the Leeds and Selby Railway it is eight feet; on the London and Birmingham it is six feet; while on the Stockton and Darlington Railway it is only about four feet.

At a little distance from us on either side we observe mounds of earth now being fast covered with green. It is the soil thrown out of the excavation, of which no use could be made. They are termed *Spoil Banks* because they are of no use, but having the inclinations of their sides very easy, may hereafter be turned to use for agricultural purposes.

But we are approaching the busy habitations of man, the ground around us is laid out in gardeus and nurseries, with here and there a paddock lying between, attached to houses of genteel appearance, and again we are within the very precincts of the town itself. Land is here exceedingly valuable, and the space that would have been occupied by the slopes of the mound over which we haste would be too valuable to be lost. The engineer has consequently done away with them, and substituted in their place a couple of walls of solid masonry or rather brickwork, varying in height, according to the surface of the ground. This is the plan adopted on the London and Birmingham Railway on its approach to Euston Square.

Again we have left behind us the groupings of interest, and the anxieties of worldly pursuit, and the sounding gratings of the wheels of the train tell us that we are passing the stream which we first saw at starting. It here takes a detour, and the suddenness of the bend has

created a difficulty which is met by a beautifully turned oblique archway. It is we perceive the first of a series, for a viaduct of considerable length has been raised to enable us to cross the luxuriant water-meadows, filled with noble oxen grazing on its richness for a metropolitan market. The arches are tall and narrow, bearing a strong resemblance to the celebrated viaduct of Segovia. Of this species of support, the most remarkable we have in the course of railway walking is that of the Greenwich Railway. It offers an instance of great skill and energy, and is perhaps the most extensive erection of the kind in the world, with the exception of that on the Appian way.

The solid earth again almost shakes beneath us. The country assumes a wilder and bolder character. A height apparently of some elevation, an inclined plane of about one in forty is before us, and a strong rope is attached to our machine, which is worked by an engine above, and thus we are drawn to the top. The greatest portion of the Canterbury and Whitstable Railway is worked by this system, as is also the Cromford and High Peak Railway, and in the Collieries in the North of England the custom is carried to a great length. Indeed in the use of railways in hilly districts it is almost a matter of necessity.

Now we have reached the summit, the rope is detached, and the conductors and their attendants are occupied in replenishing our boilers at the water station. This is an inconvenience which it would be well to

avoid, but at the present it cannot be helped on a railway of any considerable length. On the Manchester and Liverpool Railway there is but one, the distance between the termini being about twenty-nine miles and a half. There are four stations on the Clarence Railway, each consisting of an iron tank ten feet square, and four feet high, fixed on the top of a brick building seven feet high.

Now we are replenished, and again we start; farther the country seems to recede beneath our feet, and our ponderous conveyance darts along the summit of an embankment having an inclination, but insufficient to oblige the help of a stationary engine. The country seems to slope to the foot of the mound, partly perhaps from the effect of perspective, and partly no doubt from a real descent. Within a short distance of the embankment an open drain has been left in which the residuary waters may be collected and carried off. Even now it is trickling at the bottom. Now we have passed a little gully. It is a trough formed of tiles for carrying down the water from the top of the embankment to the drain below. Now the low drain increases, doubtless necessarily so from its having received the top water, anda brook, that winds out of the sedge from beneath those ash trees, has brought its tributary aid to swell the stream. It runs along the side for a short distance and has disappeared. The conductor points out to us that it is to be seen on the other side. It has passed it seems beneath a *culvert*

or large drain formed of brick, by which means suc convenience is often obtained.

Again there is a defile. The returning engine meets us, and the ears are almost dinned by the noise as the monsters dart past each other. Already are they far apart, and the open country gladdens us again.

A prospect of glorious and rich fertility lies spread around us. Far as the eye can reach, nature tamed by art seems decked in beauty. Villages, homesteads, and farms are thickly scattered, and the bright blue sky, with here and there a fleecy cloud hardly stirred, resting in the far ether, forms a perfect concave over our heads, seeming to touch the ground on a level with our feet on every side. So perfect is the level, that the carriages seem almost motionless, and were it not for an occasional catching of the breath we could not imagine the rapidity of our course. An hour has passed, and still we look upon the same features of this entrancing landscape. Another, and there is a dim haze in the distance. A blueish cloud seems to rest upon the earth. Now it is ragged and unequal. The bulgings of substantial erections are seen through the vapour, and now the various buildings, the spires, the towers, the chimnies, and the houses themselves in their proper forms are seen clearly in the bright sun-light, and a beautiful picture is now annihilated. The suburbs are passed, we have arrived at the termination of our delightful journey.

Now let us examine most particularly the structure of this wonderful contrivance, by which we have been enabled to travel so far so pleasantly, and in so short a time.

In appearance it is but two sets of parallel iron rails, almost bright with the friction, raised a little above the ground. Far as the eye can penetrate, the highway continues level as a floor, and its course is only lost to the sight by the interposition of the floating globules, which show us that we have strained the nerves too long. But much more of art must exist than is apparent. No small firmness of structure is requisite to sustain the strains of the ponderous machines which pass with such velocity, and so frequently over those small bars of metals. The width of the space on which the rails are laid down is between thirty and forty feet, nearer the latter than the former width.

The rail which appears upon it is termed an edge rail, and is the form in which rails are now generally made, causing much less friction, from the smallness of the surface presented to the tire. The rails are made in fifteen feet lengths with a flanch, curving from the middle to the sides, and its strength is varied according to the weight which is expected to pass over it. The weight of the rails on the Liverpool and Manchester Railway, at least those which were originally laid down was thirty-five pounds per yard, but rails of above double that weight, and accordingly double that strength, are now being substituted. They are still however re-

tained on the Stockton and Darlington, Leeds and Selby Railways. A rail of thirty-five pounds to the yard will measure three inches and a half in depth, and two and a quarter in width of the upper flanch, and the upright portion is three quarters of an inch thick.

The weight of the rails laid down upon the Birmingham Railway at the first was fifty pounds, but those chiefly laid down are the same size and strength as the new rails on the Liverpool and Manchester. Nor is there only a difference in the size and weight, but a difference has also been made in the shape of the rail. The former kind which we have described is called the "fish bellied" rail from its bulging out in the middle underneath.

The latter are termed parallel rails, and are of the same thickness and breadth all the way through. They were substituted, as we have stated in a previous page, by the advice of Professor Barlow, after the experiments made by him at the instance of the London and Birmingham Company. The rails of the Leeds and Selby, the Bolton, the Clarence, the Dublin and Kingston, and the Greenwich railway, as well as the seventy-five pounds rails on the Birmingham, and the Liverpool and Manchester railways, are parallel or straight rails but those of the Leicester and Swannington, the Whitby, the Newton and Warrington, and the Darlington Railways are of the fish-bellied form. Cast iron is now wholly disused, and the malleable or wrought iron which has been rolled is now universally substituted. As we have just stated, the usual length now is fifteen

feet; formerly they were made only a yard long, but though the rails seemed to be stronger, so many joints were caused that the present length has been adopted. The cost of rails throughout the line of the Birmingham Railway to London is stated at 460,000*l.*, and their weight at 35,000 tons.

The rail is attached to the block or sleeper on which it rests, by means of what is called a *chair*. Chairs are usually made of cast iron, and generally about nine inches in length, by about half that length wide, and having an upright socket into which the rail is fixed, by means of a wedge driven in between one side of the rail and the socket. The pedestals or chairs on the Liverpool and Manchester Railway are fourteen inches long and six inches wide, by one and a half thick, and having six perforations, three quarters of an inch in diameter, two for securing the chair to the stone, and four for securing the rail to the pedestal. Through these perforations screw-bolts are passed and secured to the flanch of the rail by sexagonal nuts. The chair is placed upon a block of stone, or wood, when of the latter material it is called a *sleeper*, and between them a square of *felt* is placed, which forms a compact medium between the sleeper and the chair. The pieces of felt used in a mile of double way is 7040.

The *blocks* are usually made of granite or other hard stone, and are chiefly used on embankments or cuttings, but care is taken not to lay them down until the subsidence of the mound has entirely taken place. The

blocks on the London and Birmingham, and on the Greenwich railway are each four cubic feet. On the Birmingham Railway they are set diagonally, and are placed at distances of three feet from middle to middle, where the fifty pound rails are laid down, but at the distance of fewer feet where the larger rails are used. On some railways the blocks are placed in a continuous line, being bound together by iron ties. On the Bolton and Preston Railway the blocks are five feet in length, two feet wide, and embedded on brick sleepers, and without any ties to connect them. The blocks on the London and Birmingham railway are estimated to weigh 152,460 tons, and their cost is stated to have been 180,000*l.*

Sleepers are usually made of larch, fir, or oak, are about nine inches wide, six feet long, and five inches thick. They are placed across the line of way about three feet from middle to middle, and the chairs are spiked down to them, and are frequently used on embankments before the subsidence has fully taken place. Whenever a line passes through a country where the species of timber grows extensively of which they are formed, they are sometimes used altogether instead of stone, as is the case on the London and Southampton railway. But they are subject to decay, and on the Leicester and Swannington Railway they are now being rapidly replaced by stone. The wedge used for securing the rail to the chair is called a *key*; they are generally of iron, but on the London and Birmingham Railway *oak wedges* have been used.

Professor Barlow has given the following estimate to the Directors of the London and Birmingham Railway, of the length, number, and weight of rails, with the necessary length of bearing.

	LENGTH OF BEARING.				
	3 Ft.	3 Ft. 9 In.	4 Ft.	5 Ft.	6 Ft.
Length of rail, ... feet	15	15	16	15	12
Weight of one rail,............ .... lbs.	257	294	326	337	316
Number of rails in four lines, ... per mile	1,408	1,408	1,320	1,408	1,760
Weight of rails per mile, ... tons	161	185	192	212	248
Number of joint chairs and joint blocks......	1,408	1,408	1,320	1,408	1,760
Weight of joint chairs & pins per mile, tons	17½	19	17¾	20¾	26
No. of intermediate chairs & blocks, per mile	5,632	4,724	3,960	2,816	1,760
Weight of intermediate chairs & pins per mile	60½	47¼	44¼	34	21¼
Total weight of rails, chairs & pins per mile, ... tons	239	251¼	254	266¾	295¼
Cubic feet in joint blocks, ...per mile	7,040	7,040	6,600	7,040	8,800
Cubic feet in intermediate blocks, .. per mile	22,528	16,896	14,840	11,264	7,040
Total number of cubic feet of stone used for blocks, ...per mile	29,568	23,936	21,440	18,306	5,840

An endeavour is always made to keep a railway in a direct or straight line, and such is undoubtedly the best form if it could be observed, but from the nature of things, it is almost in most instances impossible; and if it were not so, there still would exist a necessity for *curves* out of the direct course. In a single line of rails they are necessary in order to enable proceeding and returning trains to pass each other, and where double lines are laid down they are still requisite. The tendency of the wheels of the carriages is to pursue a direct course, and just so in proportion to the velocity at which they move, care is therefore requisite to form the curves of a sufficient radius, to prevent the trains starting from the rails. On the Liverpool and Manchester Railway the least curvature is thirteen chains, and on the Leeds and Selby half a mile is the minimum. In order to obviate the liability to accidents, engineers have also placed conical tires to the wheels of the engine, and have also made the outer rail a little higher than the inner one; thus not only allowing the wheels to run in different curvatures, but also adding the power of gravity to counteract the centrifugal force.

The term *gradient* is used to express the degree of inclination of an ascent or descent, and a plane is said be at the *angle of repose*, when the friction of a train and its gravity are equal, and thus the wheels will stand without slipping.

We have seen that by slow degrees the steam engine progressed until it was applied to the service of loco-

motive engines. From the year 1815 the attention of scientific men had been especially directed to this point, and after 1820 the improvements made were very considerable. They had been used for some time before they were put on railways, but were much more rapidly improved afterwards. They were first substituted for the use of horse power on the Stockton and Darlington railway, and though the machines there used are clumsy in their construction, they are still very powerful. The *Lord Brougham* for instance is sixteen feet in length, supported by six heavy wheels, each of which is four feet in diameter, and the weight of the whole concern is as much as twelve tons. The piston works vertically, and communicates with the wheels beneath by means of cranks attached to them.

Various improvements have been made, but a step was decidedly taken, when in consequence of the premium of five hundred guineas offered by the Liverpool and Birmingham Company, the trial of the several engines took place on their line previous to its being opened. It was adjudged to Mr. Stephenson, of Newcastle, for his engine termed the Rocket. The number now used is nearly one to every three miles, and the same number are kept for relays and under repair, making at least a score of engines engaged on one railway. Some of them are large and powerful. On the Dublin and Kingston Railway, the number of engines is nine, starting almost twenty times a day from each end of the line. The weight of these engines is about nine or ten

tons. Upon the London and Birmingham Railway, the traffic is already very great, and we may fairly contemplate a great increase in the number of engines which have already been placed upon the way.

Two of the most powerful engines that have ever been placed on any railway, are the Vulcan and the Atlas, upon the Leicester and Swannington Railway. They each possess cylinders of sixteen inches diameter, making a twenty inch stroke. The other engines on the same railway are also very large, being used chiefly for the traction of coal.

The *carriages* which have been introduced on railways are all, or at least most of them, of beautiful construction. Those upon the Liverpool and Manchester Railway possess many advantages both of beauty and convenience, but still they have been far surpassed by those placed on the Great Western Railway by Mr. Brunel, and are replete with every convenience, and even luxury, being indeed almost gorgeously fitted up. They are particularly spacious and complete, with sofas and all the appliances for the agreeable occupation of time. Their ultimate expense will no doubt greatly exceed that of those on the London and Birmingham Railway, which has already amounted to more than 150,000*l.* The first class carriages of the Liverpool and Manchester Railway are divided into three compartments like a French *diligence*, each containing ample room for six persons, the extreme length being fourteen feet, and the width seven feet.

The second class carriages have seats for twenty-four persons, and are open at the sides. Some of the carriages on the Greenwich Railway are without the divisions, having seats all round except where the doors intervene. Mr. Hargrave stated, in evidence before the House of Commons, that the cost of each engine is 2,000*l.* per annum. The height of the chimnies of the engines is generally about twelve feet, and they are provided with *cowls* of strong wire gauze of demi-globular shape for preventing flakes of fire from escaping from the chimnies. On the Newcastle and Carlisle Railway, they have, however, been discontinued, being found to produce no good effect. Attached to the carriages is a sort of apparatus for the purpose of preventing the sudden shock which would otherwise be experienced by the passengers on the stopping of the carriage; it is called the *Buffing Apparatus.*

The ropes used for drawing carriages up inclined planes are required to be from one to two inches in diameter or even more. That used on the Canterbury and Whitstable Railways is an inch and a half, and its value is about 2*s.* 2*d.* per pound. It is passed round a drum or cylinder called a *rope roll,* which is usually made of cast iron, and is worked by a stationary engine, that winds the drum round as the train is drawn up. Those on the Canterbury and Whitstable Railway are five feet in length, and four feet in diameter. To diminish the friction *sheaves* are used, which are usually ten or twelve inches in diameter. They are set in

iron frames, let into stone blocks, on the Whitby and Pickering Railway, where there are also wooden rollers about six inches in diameter.

In the carriage of so great a weight, it is naturally to be expected, that a considerable friction is occasioned. This has been ascertained from experiment to be about seven or eight pounds per ton, and a train of sixty tons will require its engine to exert a power equal to 460 to 480 pounds, to overcome this resistance. This is accordingly increased if on an inclination, and according to the proportion of the rise; for an ascent of about one in fifty, the opposing weight of ten tons will be equal to that of sixty on a level.

The velocity at which locomotive engines move on railways varies of course exceedingly with different circumstances. The degree at present used is far from that which it is known might be easily attained. The average speed of the trains with the first class carriages on the Manchester and Liverpool Railway is about twenty miles an hour, including the ascents of the Whiston or Sutton inclined plane. There is only one stoppage at Newton, to take in water. The second class is generally about two hours on the journey. On one occasion when the snow was on the ground, the night train performed the first fifteen miles in thirty-five minutes, which is about twenty-five miles an hour; which is the speed to which the carriages are proposed to be limited on the Great Western Railway. This is undoubtedly moderate, compared with what we know of

the capabilities of steam locomotion on railways, but low as it certainly may be said to be, it is undoubtedly an amount which a few years since was rather to be desired than looked for.

We here extract for the information of our readers the account of three experiments made by Dr. Lardner on the powers of locomotive engines, and given in his History of the Steam Engine:

I.

"On Saturday the 5th of May, 1832, the engine called the *Victory* took twenty waggons of merchandise, weighing, gross, ninety-two tons, nineteen cwts., one quarter, together with the tender containing fuel and water, of the weight of which I have no account, from Liverpool to Manchester, thirty miles, in one hour, thirty-four minutes, forty-five seconds. The train stopped to take in water half-way for ten minutes, not included in the above-mentioned time. On the inclined plane, rising one in ninety-six, and extending one and a half mile, the engine was assisted by another engine called the *Samson,* and the ascent was performed in nine minutes. At starting the fire-place was well filled with coke, and the coke supplied to the tender accurately weighed. On arriving at Manchester the fire-place was again filled, and the coke remaining in the tender weighed. The consumption was found to amount to 929 pounds net weight, being at the rate of one-third of a pound per ton per mile.

"Speed on the level was eighteen miles an hour; on a fall of four feet in a mile, twenty-one and a half miles an hour; fall of six feet in a mile, twenty-five and a half miles an hour; on level ground, sheltered from the wind, twenty miles an hour. The wind was moderate, but direct a-head. The working wheels slipped three times on Chat Moss, and the train was retarded from two to three minutes.

"The engine, on this occasion, was not examined before or after the journey, but was presumed to be in good working order."

II.

"On Tuesday the 8th of May, the same engine performed the same journey with twenty waggons, weighing gross ninety tons, seven cwts., two qrs., exclusive of the unascertained weight of the tender. The time of the journey was one hour, forty-one minutes. The consumption of coke 1,040 lbs. net weight, estimated as before. Rate of speed.

Level	$17\frac{5}{8}$	miles per hour.
Fall of four feet in a mile .	22	"
—— six " . . .	$22\frac{1}{2}$	"
Rise of eight " . . .	15	"

"On this occasion there was a high wind a-head on the quarter, and the connecting rod worked hot, owing to having been keyed too tight. On arriving at Manchester I caused the cylinders to be opened, and found that the pistons were so loose, that the steam blew

through the cylinders with great violence. By this cause, therefore, the machine was robbed of a part of its power during the journey, and this circumstance may explain the slight decrease in speed, and increase in the consumption of fuel, with a lighter load in this journey compared with that performed on the fifth of May.

" The Victory weighs eight tons two cwt., of which five tons four cwt. rest on the drawing wheels. The cylinders are eleven inches diameter, and sixteen inches stroke, and the diameter of the drawing wheels is five feet."

III.

" On the twenty-ninth of May, the engine called the *Samson* (weighing ten tons, two cwt., with fourteen inch cylinders and sixteen-inch stroke; wheels four feet six inches diameter, both pairs being worked by the engine; steam fifty pounds, pressure 130 tubes) was attached to fifty waggons, laden with merchandize, net weight about 150 tons; gross weight, including waggons, tender, &c., 223 tons 6 cwt. The engine with this load travelled from Liverpool to Manchester, thirty miles, in two hours and forty minutes, exclusive of delays upon the road for watering, &c., being at the rate of nearly twelve miles per hour. The speed varied according to the inclinations of the road. Upon a level it was twelve miles an hour; upon a descent of six feet in a mile it was sixteen miles an hour; upon a

public, and after a few months sufficient indication was given, that the experiment was likely to prove in every way satisfactory. The excessive cost was counted as nothing, for the intercourse which had existed between the two towns prior to the opening of the railway was more than quadrupled. The benefit which the successful termination of this undertaking occasioned was soon felt, and its influence became perceptible in the increased activity of those who were maturing even far more extensive schemes.

The wild propositions which were put forth for public approval were, doubtless, both injudicious and injurious, and many a broken heart, while mourning in secret, bore testimony to the fatal worship of the moloch of wealth. Yet were they nevertheless productive of this great good, that they turned the powers of intellect to the concoction of plans of public good which were speedily brought into effect. In 1825, the act was passed through both Houses of the Legislature for the construction of a railway from Canterbury to Whitstable, for the purpose of establishing a more direct and easy communication with the sea. The work was carried on through a country of very variable character; so much so, indeed, that the chief portion of the distance is worked by stationary engines, in some places being very steep, the line rising 200 feet in the first two miles from Canterbury by a series of inclined planes, and at the other end descending 220 feet towards Whitstable. The length of the whole line which

is something more than seven miles was executed in the face of unexpected and unusual difficulties, and was not opened to the public until the 3rd of May, in the year 1830. Benefits of considerable value almost immedietely flowed from its institution. Of all the necessaries of life, coal is that which is most scarce and dear in the southern counties of England, and prior to the completion of the Canterbury and Whitstable railway, the carriage from the water side to the former place, was as high as eight and sometimes even twelve shillings a ton, but on the opening of the new road, the price immediately dropped to four shillings and sixpence, and an equal proportion held with every other species of merchandize. Nor was the passenger traffic a less advantageous criterion of the utility of the way. Before it was established the number of individuals who passed between the two places was estimated at 4,000, while after the opening of the railway the number had increased to 26,000 at the trifling charge of ninepence each. The facility thus afforded led also to another advantage. The position of Whitstable was found to be so excellent as a port of debarkation for coals and other goods, that a tidal harbour was formed. which was opened two years afterwards, and thus a permanent increase of the trade, and, consequently, the comforts and intelligence of the district was the consequence.

It was natural that where a convenience of so much importance was being obtained in other parts of the

country, that the spirited and enterprising individuals in our manufacturing districts should be anxious and ready to avail themselves of it. The great intercourse which subsisted between the second and third cities of England, would naturally suggest to their inhabitants the adoption of railway transit, and accordingly, during the year 1822, the matter was much discussed. All attempts, however, to effect an arrangement at that time proved nugatory, and for two years the design was suffered to remain in abeyance. In 1824, however, it was again seriously taken up, and the result of the meetings which were held respecting it was the formation of a Company for making a railway throughout the whole distance between Liverpool and Manchester. In the following year they applied to the House of Commons for an act of incorporation, but failed.

Prejudice was actively alive against the institution of such a way, and many doubts, groundless, as it has happily proved, were entertained of its practicability.

In the next year their application was renewed, and in the course of that session it was successful.

Ground was almost immediately broken, and the design was perseveringly carried on till its completion. Difficulties of uncommon magnitude were experienced during its execution, especially in the consolidation of a road over the bog called Chat Moss. By laying down a bottom of hurdles, and rearing a judicious superstruc-

ture upon them, however, it was overcome, and even this unsubstantial stratum was made firm and enduring for the passage of the most weighty trains. On the 15th of September, 1830, within about four years after its commencement, the whole line of way was opened, with proceedings and festivities worthy of the great design they were intended to celebrate, and the following day the public were admitted to a participation of its advantages. These were soon felt to be as real and as numerous as its most sanguine projectors had anticipated, indeed it may be reasonably asserted that they were more than any one could have imagined.

The cost of the execution of this railway was originally estimated at 500,000*l.* or about 23,000*l.* per mile, but that was very considerably increased, and its ultimate amount turned out to be about 900,000*l.* or 30,000*l.* per mile. This certainly was an immense increase upon the original statement, but surprise cannot be entertained at the excess if the difficulties of making the way be taken into account. But if the expense was great, the benefits which accrued from its outlay were felt to be fully commensurate. The number of coaches passing daily between the two places was twenty-two prior to the establishment of the railway, with six extra in summer, and the number of passengers on the average 450, being a weight respectively of passengers and luggage of about 178lbs. Within the first seven months, the number of passengers carried by the railway was nearly 255,000, and

within the first two and twenty months after its opening —a period which allows us to strike as fair an average as can be computed— the number was nearly 670,000 or about 1200 a day. The time previously occupied in a journey from one place to the other was about five hours, and the fare about seven or eight shillings; after the railway got to work, the fares by the first class carriages was five shillings; and the time occupied in travelling was reduced to an hour and half; and by the second class carriages it was no more than two hours, at a fare of three shillings and sixpence each. The repairs of the engines were stated by the Directors to be an expense of more than 18,000*l.* and the maintenance of the way was stated in the Report of the 30th of June, 1834, to be 623*l.* per mile.

The average speed at which the carriages travelled on the first opening of the road was something more than sixteen miles an hour, but that has since been very considerably increased.

Dr. Lardner has stated that the engines are capable of dragging a train of ninety tons at the rate of twenty miles an hour, thus performing a journey from Manchester to Liverpool in two hours, which would require the exertions of not less than two hundred and seventy horses for a day of nine hours duration. Before the establishment of the railway, the charge for carriage by the canal was fifteen shillings a ton, while now, both by railway and canal, it is not more than ten, and that which occupied a period of twelve hours is done in two.

The whole number of passengers conveyed upon the railway does not quite average what we have just stated, 1200 per day. From the opening of the line on the 15th of September, 1830, to the end of June, 1836, the gross total was 2,393,767, making an average of 1,132 persons every day. Several circumstances arose to render the number during the several years somewhat variable, but upon the whole the increase has been regularly progressive.

In 1832 the number was 356,945; in 1833—386,492; in 1834—436,637; in 1835—473,847; and in 1836, January to June,—222,848, being an excess during the last six months of 17,000 over the first six months of the preceding year.

The sums received during the same half year were

Coaching Department......	£54,685	6	11
Merchandize Ditto..........	39,957	16	8
Coal Ditto..................	2,591	6	6
Total	97,234	10	1
The total Disbursements...	56,350	1	9
Showing a profit of six months...	£40,834	8	4

In the corresponding six months of the following year the net profit was above 46,000*l.*

The number of persons employed upon the railway is between 700 and 800, at a salary of 855*l.* 10*s.* 4*d.* per week.

The facilities thus afforded are manifestly exceedingly

great, and much more indeed than even these statistical statements can represent. A merchant or manufacturer is now enabled to transact that business in person which formerly he was compelled to do by letter. In the course of a few hours his personal superintendence can be given to his business in both places, and be actually done at less expense than it was before, and even should it prove inconvenient for him to move from one place to another, the means of epistolary communication are almost as ready and as speedy between the two cities as they are through the medium of the twopenny post between different parts of London, the mail passing each way three times in every twenty-four hours. Much endeavour was made to undervalue the benefits of the railway, both to the shareholders and the public, but it is now happily alike disregarded by the proprietors and the public. How far these fears are justified may be ascertained by the following account which we abstract from the Companion to the British Almanack for 1837. The statement of anticipations is drawn from the evidence of gentlemen who were put forward as witnesses before the Committee of the House of Commons, prior to obtaining the Act of Incorporation for the Company, and the statement of results is taken from the half yearly reports of the directors to the several shareholders.

1. The capital of the company is 510,000*l.* with power to borrow 127,500*l.* Lord Stafford has 1,000 shares, or one-fifth of the whole concern. He appoints three directors; twelve are elected by the other shareholders

Deposit, *5l.* per share. No person allowed (as an original subscriber) to hold more than ten shares. The scrip or certificate declares the name of the person to whom it was granted, and that no transfer is allowed until the Act is obtained.

It is proved that the modes of communication between the termini are not sufficient, and that great delays take place.

The prices charged are for Cotton 15*s.* per ton.; Corn 10*s.*; Sugar 12*s.*; Return goods 10*s.* The railroad engages to carry the first at 11*s.* per ton; second at 9*s.*; third at 9*s.*; fourth at 11*s.* per ton. The tonnage rates to be reduced 5 per cent. for every £1 per share, the company divides above £10 per share.

Inside fare in coaches 10*s.*—Outside 6*s.*

Railroad fares 7*s.* 6*d.* to 3*s.* 6*d.*

The public have been benefitted by the railway in the reduction of charges as follows, in the last year:—

2*s.* 6*d.* each on 500,000 passengers . .	£62,500
2*s.* 6*d.* .. 450,000 tons of goods, by all conveyances	55,250
2*s.* per ton on 1,240,000 tons of coal, for the supply of Liverpool and Manchester, the price of which has been reduced in consequence of the reduction of charges per railroad	124,000
Total per annum . .	£241,750

Besides rapidity of communication, which, in a commercial country, is invaluable.

2. The number of passengers expected is half the number the coaches can take, which was found to be from 400 to 500 per day. Fares 10*s.* inside, 6*s.* outside. They carry four inside and twelve outside.

The greatest number of passengers the coaches could carry, in 1825, was 600 per day: average 450. They paid, on an average, 7*s.* 6*d.* each, and were four to five hours on the road—Total receipt £120,334

3. The net income expected is . . . £62,500
Net receipt £83,619

4. No competing line in existence, in progress, or in contemplation.

Application has been made to Parliament for a new line, but without success.

5. The sum of 510,000*l.* is considered sufficient to complete the work.

The works have cost nearly 1,200,000*l.*

6. The expenses will be thirty-three per cent.

The expenses amount to sixty-two per cent. on gross receipts. In this are included the cost of collecting and delivering goods, interest of money, and duty on passengers.

7. Satisfactory evidence produced that the receipt will pay the expenses, and a fair remuneration.

The net revenue, after paying all charges and expenses, is rather more than ten per cent. on the shares.

8. The petitioners against the Bill were three water-companies, all contending that additional communication was not required.

The line of road was altered to avoid the property of some dissentients, to their disappointment at the present day. One of these, a lady, has land near the station at Manchester. Her surveyors thought the value of it would fall from *6d.* the price then given, to *4d.* per yard, chief rent; whereas it has risen to *1s. 6d.*

9. Stress was laid by its opponents upon the inconvenience and dangers to arise from using engines.

In proof of the great safety of railroad travelling, on the 17th of April, 1836, a locomotive engine, going at the rate of twenty miles an hour, with a train of carriages, broke its axletree, ran off the road down an embankment of thirteen feet; two of the carriages were overturned, when only one person was slightly hurt in attempting to get out of the window.

The fatal accidents have been very few, and have in almost every instance arisen from the persons who met with the same acting in opposition to the directions given by the railway directors.

The attention which was excited by the discussion of this important matter, while it was pending in parliament, drew the attention of the manufacturing and commercial interests very strongly to it: and the advantages of railways became so apparent that plans

were shortly devised for the accomplishment of lines between places of leading importance in every part of the country. Companies were speedily concocted for their accomplishment, and much ruinous speculation was the consequence. From year to year they continually increased, until in the session of last year the number which passed the legislature amounted to thirty-five, intended to occupy a length in the aggregate of eight hundred and fifty miles.

The first act which was passed for the forming of a railway was carried through parliament in 1801, and, with the exception of very few sessions, one act or more has been passed every year since, progressively increasing in number up to 1837.

The following is a statement of the number and periods when they passed :—

1801—1	1815—1	1827—6
1802—2	1816—1	1828—11
1803—1	1817—1	1829—9
1804—1	1818—1	1830—8
1808—1	1819—1	1831—9
1809—2	1821—1	1832—8
1810—1	1823—1	1833—11
1811—3	1824—2	1834—14
1812—2	1825—5	1835—18
1814—1	1826—6	1836—35

Up to 1825, the number of acts of parliament passed for the formation of railways was twenty-four,

comprising about two hundred and fifty miles of road. In these, however, there was not one of any great public importance; but that period had scarcely elapsed ere the benefits offered by the opening of lines directly to the heart of the manufacturing districts became apparent, and some of the most important designs that have ever been entertained for the promotion of commerce were readily and eagerly discussed. The advantages also of communications with the South and East coasts, and passing through the heart of most of the agricultural countries, were speedily appreciated.

In 1829 an act had been passed for the formation of a line beginning at Newton, on the Manchester line to Warrington, in Staffordshire, which in the session of 1833 was farther enlarged by giving permission to continue it to Birmingham, thereby connecting the two first commercial cities in the empire and the two first ports in the world with each other by a rapidity of transit which brings them within ten hours of each other. During the present year the whole of the line has been made available for the public.

In 1829 an act was obtained for a line of railway to connect the city of Carlisle with Newcastle, a distance of sixty miles. It was opened for public traffic on the 18th of June of the present year, and has hitherto more than fulfilled the designs of its promoters, and has connected by its completion, the German Ocean with the Solway Frith. It begins in a place called the *Close*, in Newcastle, and is carried in a westerly direc-

tion, nearly parallel to the River Tyne to Hexham, and then curving it runs on to Acomb Hermitage, then to Haydon Bridge and Haltwistle, thence to Fenton, and ends at the Carlisle Canal, which communicates with the sea. Another way is also being formed from Newcastle to North Shields, and ending on the quay.

The *London and Southampton Railway*, for which an act was obtained in 1834, begins at Nine Elms, Battersea, and is intended to be carried to the beach of Southampton Water. During the last twelve months it has been very actively carried on, and on the 21st of May last was opened as far as Woking Common, a distance of twenty-three miles. During the first three months after it was opened, nearly 94,000 persons were carried upon it. In the following year an act was obtained for making a line with Brighton, after an expenditure of money and ability most probably unequalled on any undertaking in the annals of commerce. Not less we believe than eight lines were in the first place designed between Brighton and London, and when after much endeavour these were reduced, three were retained with unwonted tenacity, and the matter was at length only settled by a compromise. In the following year an act was passed for the formation of a line between London and Dover, under the appellation of the South Eastern Railway. An act had previously been obtained for the formation of a line to Greenwich only, which was undertaken

with a view to carry it forwards to the chief outlet to France.

Other acts have been obtained for connecting the metropolis and the principal shipping coasts of the country, and thus, a railway communication has been established which ramifies throughout the whole of the country, and others are projected which will render the means of communication with every internal part both rapid and easy. To attempt fully to describe them all would occupy a space far more than can here be afforded, and we must therefore be content with a summary of those which have already been accomplished, or are so near completion as to be entitled to the supposition that they are finished and likely soon to be in action.

The other public railways, according to the best information we can obtain are as follows:—

The *Surrey Iron Railway* was secured by act of Parliament in 1801. It extends from Wandsworth to Croydon, with a collateral branch to Carshalton. Its length is about nine miles, and the cost of its construction was £60,000. The object proposed by its establishment was the facilitation of conveying agricultural product to London, and the return of manure, &c., to the country.

The *Caermarthenshire Railway* was constructed in 1802, for the conveyance for shipment of limestone, coal, &c. to the basin at Llanelly, where it terminates.

It is sixteen miles long, and extends from a place called the *Flats*, to the parish of Llanfihangel, Aberbythick. Its expense was £35,000.

The *Sirhowey Tramroad* was undertaken by the Monmouthshire Canal Company, in conjunction with the Proprietors of the Tredegar Iron Works, and extends from the canal of the former Company to the Sirhowey furnace. Its length is eleven miles, and its cost was £45,000.

The *Croydon, Merstham, and Godstone Railway*, was constructed in 1803. It is a continuation of the Surrey Iron Railway, and commences at the end of that work at Croydon, whence it runs by the Brighton Road to Merstham and Ryegate. A branch connects it with Godstone Green. Its length is about 15¾ miles, and it cost £90,000. Its object was the conveyance of coal to and from London.

The *Oystermouth Railway* commences at Swansea, at the end of the Canal, and runs to Oystermouth, a distance of about six miles. The cost was about £12,000. It is found a great convenience for the carriage of mineral products to Swansea. It was formed in 1804.

The *Kilmarnock Railway* connects Kilmarnock and Troon, a distance of about ten miles, and cost about £40,000. Its object was the conveyance of coal, limestone, and other produce, to and from the great works in its neighbourhood.

The *Bullo Hill, or Forest of Dean Railway*, was made

to convey coals, timber, iron ore and other minerals, found in the forest of Dean, for shipment on the river Severn. It proceeds from the top of the hill, above Churchway Engine to the banks of the Severn, near the town of Newnham. There are three branches from the line to the different coal mines in the forest. Its length is seven miles and a half, and the capital of the Company is 125,000*l.* It was constructed in 1809.

The *Severn and Wye Railway* connects those two rivers. It commences at Lidbrook on the Wye, and terminates at the Lower Verge, near Newern in Gloucestershire. It is connected with the Severn at Nass Point by a canal one mile long. Its length, including branches, is about twenty-six miles, and the capital of the company 110,000*l.* Its object and use is much the same as that of the preceding railway, and it was made in the same year.

The *Monmouth Railway* was formed in 1810. It is also connected with the Forest of Dean, and runs from a place called Howler Slade to the town of Monmouth. The company's subscribed capital was 22,000*l.*

The *Hay Railway* commences at the wharf of the Brecknock and Abergavenny canal, near Brecon, and ends at Parton Cross, in Herefordshire, after a course of twenty-four miles, and passing through a mountainous district. The capital proposed for its construction was 50,000*l.*

The *Llanfihangel Railway* commences near the same place, and ends at Llanfihangel Crucorney, in Monmouthshire. Its length is about six miles and a half, and the capital subscribed was 20,000*l.*

The *Grosmont Railway* commences at the termination of the last railway, and runs to Llangua bridge, between Abergavenny and Hereford, about seven miles. The money raised to construct it was 13,000*l.* It was made in 1812.

The *Penrhynmaur Railway* commences at the Penrhynmaur coal works, and is carried to Red Wharf, in Llanbedbroch, in the county of Anglesea, with a branch for a short distance northwards, on Red Wharf Bay. It is something above seven miles long, and consists of a series of inclined planes. The capital was 10,000*l.*, paid by the Earl of Uxbridge and Mr. Holland Griffith. The railway was constructed in the same year as the preceding.

The *Mamhilad Railway* runs from the bank of the Abergavenny canal to Usk Bridge, in the county of Monmouth, rather more than five miles. It was formed in 1814, at a cost of 6,000*l.*

The *Gloucester and Cheltenham Railway* commences at the basin of the Gloucester and Berkeley canal, in the City of Gloucester, and ends at the Knapp toll-gate at Cheltenham, about nine miles. The object was to supply Cheltenham with coal at a cheaper rate than by the common road conveyance. It was formed in 1815.

The *Mansfield and Pinxton Railway* runs from the Bull's Head Lane, in the town of Mansfield, to Pinxton basin, near Alfreton, in Derbyshire, where it communicates with a portion of the Cromford canal. It has a branch of about a mile and a half in length, which runs near the Codnor Park Works, and the new line of the Cromford canal. The whole was constructed in 1817, at a cost of 32,800*l.* It is used chiefly for the conveyance of coal and lime, both of which are much used in that district of the midland counties.

The *Kington Railway* is a continuation of the Hay railway, running from Parton Cross to Kington, in Herefordshire, and thence to the lime works near Burlinjob, in Radnorshire, about fourteen miles. It was constructed in 1818, at an expense of 23,000*l.*

The *Plymouth and Dartmoor Railway*, which was formed in 1819, runs from the Sound at Sutton Pool, a short distance from Plymouth, to Bachelor's Hall, in the parish of Lydford, near the prison erected on Dartmoor, for prisoners of war. Its length is about thirty miles, and the cost was 35,000*l.*

The *Stratford and Moreton Railway* runs from Stratford-upon-Avon to Moreton-in-Marsh, in Gloucestershire, with a branch to Shipstor-upon-Stour, in Worcestershire. Its whole length is about eighteen miles and a half, and was executed at an expense of 50,000*l.* It was completed in 1821.

The *Stockton and Darlington Railway* we have already noticed, but may include it here also in order

to notice that it was the first upon which locomotive engines were used as the moving power. It runs from the left bank of the Tees at Stockton, to Witton Park colliery, about two miles and a half from Bishop's Auckland, about twenty-five miles, which, with its five branches, together about 15¼ miles, makes the whole length of this line something above forty miles. Its cost was about 250,000*l.*

The *Redruth and Chasewater Railway* was formed with several branches in 1824, and runs from Redruth to Point Quay, in the parish of Feock in Cornwall. The length of the line, including branches, is about fourteen miles. It cost about 22,500*l.*

The *Monkland and Kirkintilloch Railway* runs from the latter place which is in Dumbartonshire, for about ten miles to Palace Craig. The cost was 25,000*l.*, and it was formed in 1824, for the purpose of transporting the iron and coal of the district to the Perth and Clyde canal.

The *Rumney Railway Company* obtained their act in 1825, and their line runs from an estate called Abertyswg in Monmouthshire, to the Sirhowey railway at Pye Corner, in the parish of Basaleg, in the same county, about two miles and a half from Newport. The expense was 47,100*l.*

The *West Lothian Railway* runs for Ryhall on the Edinburgh and Union Glasgow canal, in the parish of Upshall, to Shott, about twenty-three miles. It was constructed at an expense of 40,700*l.*

The *Cromford and High Peak Railway* runs from

a place on Cromford canal, about one mile south of that place to the Peak Forest canal at Whaley Bridge. By a series of elevations it rises to 990 feet above its starting place. Its length is thirty-four miles, and it was made at an expense of 164,000*l.* It forms a convenient mode of communication between the counties of Derby, Nottingham, and Leicester, and Manchester and Liverpool.

The *Nanttle Railway* runs from slate quarries near Nanttle Pool, in the County of Caernarvon, to Caernarvon itself. The capital of the Company is 20,000*l.*

The *Portland Railway* runs from the priory lands in Portland Island to the Castle. The cost was 5,000*l.*

The *Duffryn, Llynvi, and Port Cawl Railway,* is in Glamorganshire, between the parish of Llangronyd and Perth Cawl Bay, sixteen miles and three quarters. The cost was 60,000*l.* Its object is to open a communication between several large iron and coal mines, and quarries of limestone and freestone, and Bristol Channel.

The *Ballochney Railway* runs from a branch of the Kirkintillock railway, near Airdrie, in Lanarkshire, to Ballochney in the same County. The cost was 18,425*l.* Its use is to carry coals to Glasgow, and coal and ironstone to the furnaces near it.

The *Dulais Railway* runs from Aber Dulais to Cwm-Dulais in Glamorganshire. Its length is eight miles and three quarters, and it was constructed at a cost of 10,000*l.*

The *Dundee and Newtyle Railway* runs from Dundee to Newtyle, through a very hilly country, in which

an elevation of 554 feet is to be overcome. The waggons are worked on inclined planes by stationary steam engines, but coaches have for the last three years been impelled by locomotive engines. Its length is eleven miles, and it was constructed at an expense of 50,000*l.* It connects the agricultural district of Strathmore with Dundee and the river Tay.

The *Edinburgh and Dalkeith Railway* begins near Salisbury Craig, at Edinburgh, to the banks of the South Esk, near Newbattle. With the branch lines, the length is seventeen miles and a half. It was formed at an expense of 125,000*l.*

The *Garnkirk and Glasgow Railway* runs from Cargill Colliery, near Gartsberrie Bridge, in Lanarkshire, to the junction of the Forth and Clyde, and Monkland canals, near Glasgow. It was constructed at the cost of 40,000*l.* It is eight miles and a quarter long. It was opened to the public in 1831.

The *Heck and Wentbridge Railway* runs from Heckbridge to the Knottingley and Goole canal, a distance of seven miles and a half.

The *Great Western Railway* is intended to run from London to Bath and Bristol. One hundred and seventeen miles and a half long. Its cost cannot yet be ascertained.

The *Preston and Wyre Railway* is intended to run from Preston to the mouth of the river Wyre. Nineteen miles and a half long, and is expected to cost about 150,000*l.*

The Hull and Selby Railway is intended to join

the Leeds and Selby Railway, and thus connect the woollen cloth districts with the chief shipping port on the east coast; while the railway from Leeds to Manchester will connect it also with Liverpool on the west. The length is thirty-one miles.

The *Bristol and Exeter Railway* joins the Great Western at Temple Mead, Bristol, and runs to Exeter where its termination will be on the river Exe; the length will be above seventy-five miles.

The *Midland Counties Railway* will commence on the London and Birmingham Railway at Rugby, and run by Leicester to Derby. The length will be seventy-five miles.

The *Birmingham and Derby Junction Railway* will run from the former to the latter place, where it is intended to join the North Midland Railway. The length is thirty-eight miles and three quarters.

The *North Midland, or Leeds and Derby Railway.* It will run by Belper, Chesterfield, Rotherham, and Barnsley, and join the terminus of the Leeds and Selby Railway at Marsh Lane, Leeds. The length is seventy-two miles and a quarter.

The *Sheffield and Rotherham Railway* will be about eight miles long.

The *Manchester and Leeds Railway* promises to be one of the most important railways in the whole empire; its length will be above sixty miles.

The *Newcastle and Shields Railway* runs from Pilgrim Street, Newcastle, to the New Quay at North

Shields; the length will be seven miles and a quarter.

The *Bolton and Preston Railway* is intended to connect two important places in our first manufacturing district; its length will be twenty miles.

The *Chester and Birkenhead Railway* will commence on the south bank of the Mersey, near Woodside Ferry, and terminates on the north side of Brook Street, in the city of Chester; its length will be fourteen miles and a half.

The *Chester and Crewe Railway* is a continuation of the preceding line, and will join the Grand Junction at Crewe; its length will be twenty miles and a half.

The *Cork and Passage Railway* will be a little above six miles long.

The *Dublin and Kilkenny Railway* will be seventy-three and a half miles.

The *Dundalk Railway* will be twenty-four miles long.

The *Glasgow, Ayr, and its Branches,* is intended to be fifty-seven miles and a half long.

The *Glasgow, Paisley, and Greenock Railway* is intended to be twenty-two and a half miles long.

The *Clarence and Hartle Pool,* nine miles long.

The *Lancaster and Preston* runs from the Cotton Mills, on the turnpike road, near Lancaster, to Fishergate, Preston, twenty miles and quarter.

The *London and Brighton,* with its branches, fifty-five and a half miles long, with a capital of £1,800,000.

The *Manchester and Birmingham*, with its branch running from Manchester and joining the Birmingham and Derby at Tattenhall, seventy-two miles and a quarter. Capital £2,100,000.

The *Maryport and Carlisle* joins the Newcastle and Carlisle Railway at Botchergate, Carlisle, and ends at the Basin, Maryport, twenty-eight miles in length.

The *Aylesbury* connects that town with the Great Western.

The *Birmingham, Bristol, and Thames Junction*, unites the great manufacturing district with the south-western Port.

The *Birmingham and Gloucester* serves the same purpose indirectly.

The *Bolton and Leigh*, a short or branch line.

The *Cheltenham and Great Western* brings the former place of fashionable resort into the Great Western line.

The *Gateshead and Durham* is a branch of the Great Northern Railway.

The *Haigh Railway* was established for the convenience of shipping minerals and stores in one of the chief mining districts in Cornwall.

The *London and Blackwall* is projected for the purpose of saving the expense and loss of time in transporting merchandise from our heavily laden ships in the East and West India Docks.

The *London and Cambridge* is the commencement of the great line that is intended to connect the Me- ɔpolis *with* the Northern Counties.

The *London and Norwich*, or *Eastern Counties*, will do the same thing with Norfolk and Suffolk.

The *Thames Haven Railway* is intended to connect London with a haven to be constructed near to the mouth of the river, and thus obviate the necessity and difficulty of navigating the Pool.

The *York and North Midland* is intended to connect that City with the North Midland.

The *Clarence Railway* begins at Samphire Beacon, on the Tees, about four miles and a half north of Stockton, and runs to Stockton and Darlington Railway at Sion Pasture. Length, including branches, thirty miles. Capital 200,000*l.*

The *Warrington and Newton Railway* is a tributary of the Leeds and Manchester Railway, four miles and a half long.

The *Wishaw and Cotness Railway* is a tributary of the Kirkintilloch Railway. Cost 60,000*l.*

The *Leeds and Selby Railway* runs from Marsh-lane, Leeds, to Selby, a distance of about twenty miles. The capital 210,000*l.*

The *Leicester and Swannington Railway* runs from Leicester to the village of Swannington, fifteen miles and three quarters. Capital 90,000*l.*

The *Dublin and Kingstown Railway* connects Dublin with its suburbs, and is confined almost altogether to the conveyance of passengers.

The *London and Greenwich Railway* is laid upon a viaduct composed of about a thousand arches.

THE CANALS OF ENGLAND.

DURING the eighteenth and early part of the present centuries much attention and an immense capital had been employed upon the formation of canals. They were, so far as they were calculated to supply the wants of commerce, every thing that could be desired. Upwards of 2,200 miles of water-course had been formed, and it is believed that there is not a place in England south of Durham, that is more than fifteen miles from water communication. The following list, which has been abstracted from "Fenn's Public Funds," is the most complete that we could obtain.

ASHBY-DE-LA-ZOUCH commences at Ashby-de-la-Zouch, and joins the Coventry canal at Marstow bridge. It was completed in 1805; length 26½ miles. 1482 shares of 113*l.* each; dividend 4*l.* per share.

ASHTON and OLDHAM connects the towns of Manchester and Ashton-under-Line. Completed in 1805; length, with branches, 14 miles; 1766¼ shares of 97*l.* 18*s.* each; dividend 8*l.* per share.

BARNSLEY commences at Barnsley, Yorkshire, and joins the river Calder, near Wakefield. Completed in 1799; length 15 miles; 720 shares of 60*l.* each; dividend 13*l.* per share.

BASINGSTOKE connects Basingstoke with the river Wye. Completed in 1796; length 37 miles; 1,260 shares of 100*l.* each.

BIRMINGHAM connects Birmingham with the Staffordshire and Worcester Canal; length 22 miles; 8000 shares of 79*l.* 5*s.* each; dividend, 9*l.* 16*s.* per share.

BIRMINGHAM AND LIVERPOOL JUNCTION runs from the Staffordshire and Worcester Canal, near Tattenhall, to the Chester Canal, near Acton; length 39 miles; 1000 shares of 100*l.* each.

BRECKNOCK AND ABERGAVENNY connects Brecknock with the Monmouthshire canal; length 33 miles; 1005 shares of 150*l.* each; dividend 5*l.* per share.

BRIDGEWATER AND TAUNTON connects Taunton with the

river Parret near Bridgewater; length 12½ miles; 600 shares of 100*l.* each.

Carlisle commences at Carlisle and terminates in the Solway Frith; length 11 miles; 1600 shares of 21*l.* 10s. each.

Chesterfield connects that place with the river Trent, near Stockwith; length 46 miles; completed in 1776; 1500 shares of 100*l.* each; dividend 9*l.* per share.

Cromford connects Cromford with the Erewash canal; length 18 miles; 460 shares of 100*l.* each; dividend 17*l.* per share.

Coventry connects Coventry with Trent and Mersey canal; length 22 miles; completed in 1790; 500 shares of 100*l.* each; dividend 46*l.* per share.

Derby connects Derby with the Trent and Mersey canal; length, with branches, 21 miles; completed in 1794; 600 shares at 100*l.* each; dividend 7*l.* per share.

Dudley runs from the Worcester and Birmingham Canal, near Lelley Oak, and joins the Birmingham Canal near Tipton Green; length, with branches, 15 miles. 2060 shares of 100*l.* each; dividend, £4 per share.

Ellesmere and Chester connects the Montgomery Canal with the river Mersey, near Ellesmere; length, 61 miles. 3575 shares of 133*l.* each; dividend, 3*l.* 15*s.* per share.

Erewash commences at the Cromford Canal, near Langley Bridge, and terminates in the river Trent; length, with branches, 16 miles. 231 shares of 100*l.* each; dividend, 40*l.* per share.

Glamorganshire connects Merthyr Tidvil with the river Taff, near Penarth Harbour; length, 25 miles; completed in 1794. 600 shares of 172*l.* 13*s.* 4*d.* each; dividend, 13*l.* 3*s.* 4*d.* per share.

Grand Junction commences at Braunston, in Northamptonshire, where it joins the Oxford Canal, and runs into the Thames at Brentford; length, with branches, 130 miles; completed in 1805. 11,600 shares of 100*l.* each; dividend, 12*l.* per share.

Grand Surrey commences at Camberwell and runs into the Thames at Rotherhithe; length, 4 miles. 1521 shares of 100*l.* each; besides which the company have borrowed 120,000*l.* at 4*l.* per cent.

Grand Union runs from the Leicester and Northampton Union Canal, about 4 miles from Market Harborough, and joins the Grand Junction Canal at Long Buckby; length, 45 miles; completed in 1814. 2849 shares of 100*l.* each; dividend, 1*l.* per share.

Grantham connects Grantham with the river Tre

Nottingham; length 30 miles. 749 shares of 150*l.* each; dividend, 10*l.* per share.

HUDDERSFIELD connects Huddersfield with the Acton and Oldham Canal; length, 20 miles. 6238 shares of 57*l.* 6*s.* 8*d.* each; dividend, 2*l.* per share.

KENNET AND AVON commences at Newbury, and joins the river Avon at Bath; length, 57 miles; completed in 1810. 25,328 shares of 40*l.* each; dividend, 1*l.* 5*s.* per share.

LANCASTER commences at Kirby Kendal and passes through Lancaster to Preston; here it ceases for 4½ miles, when it recommences and proceeds to Wigan, joining the Leeds and Liverpool Canal. The communication over the part where the navigation is interrupted is carried on by means of a railway; length, including railway, 76 miles. 11,700 shares of 47*l.* 6*s.* 8*d.* each; dividend, 1*l.* 5*s.* per share.

LEEDS AND LIVERPOOL runs from the Aire and Calder Navigation at Leeds, and terminates at Liverpool; length, 127 miles; completed in 1816. 2,880 shares of 100*l.* each; dividend, 20*l.* per share.

DITTO, LEIGH BRANCH; length, 7 miles. 18¾ shares of 80*l.* each; dividend, 16*l.* per share.

LEICESTER AND NORTHAMPTON UNION commences at Leicester and terminates at the GRAND UNION CANAL, with a branch to Market Harborough; length, 21 miles; completed in 1800. 1,817 shares of 83*l.* 10*s.* each; dividend, 4*l.* 10*s.* per share.

LOUGHBOROUGH. 70 shares of 142*l.* 17*s.* 6*d.* each; dividend 110*l.* per share.

MACCLESFIELD connects the Peak Forest Canal with the Trent and Mersey Canal; length 29½ miles; 3,000 shares of 100*l.* each; dividend, 2*l.* per share.

MANCHESTER, BOLTON, AND BURY, connects these towns with the Mersey and Irwell Navigation; length 15 miles; 477 shares of 250*l.* each; dividend, 6*l.* per share.

MONMOUTHSHIRE connects the Ellesmere and Chester Canal with the Severn, at Newtown, Montgomeryshire; length, 27 miles; 700 shares of 100*l.* each; dividend, 4*l.* 10*s.* per share.

NEATH connects the towns of Neath and Aberrant, in Glamorganshire; length, 14 miles; completed in 1798. 247 shares of 100*l.* each; dividend, 16*l.* per share.

NORTH WALSHAM AND DILHAM connects North Walsham with the Ant; length, 7 miles; 600 shares of 50*l.* each.

NOTTINGHAM connects the Cromford Canal with the river *Trent,* near Nottingham; length, with branches, 17 miles;

completed in 1802; 500 shares of 150*l.* each; dividend 12*l.* per share.

Oakham connects the town of Oakham with the Melton Mowbray Canal; length, 15 miles; completed in 1803; 522 shares of 130*l.* each; dividend, 2*l.* per share.

Oxford connects the Coventry Canal with the Thames at Oxford; length, 88 miles; completed in 1790; 1786 shares of 100*l.* each; dividend, 30*l.* per share.

Peak Forest connects Peak Forest with Oldham and Ashton Canal; length, 15 miles; completed in 1800; 2,400 shares of 78*l.* each; dividend, 5*l.* per share.

Portsmouth and Arundel connects the river Arun with Chichester Harbour; length, with branches, 16 miles; 2,520 shares of 50*l.* each, and 2,000 of 25*l.* each.

Regent's connects the Grand Junction Canal with the river Thames at Limehouse; length 8½ miles; 21,418 shares of 33*l.* 17*s.* 6*d.* each; dividend, 12*s.* per share.

Rochdale connects the river Calder with the Duke of Bridgewater's Canal at Manchester; length, 31½ miles; 5,669 shares of 85*l.* each; dividend, 6*l.* per share.

Shrewsbury connects that place with the Shropshire canal; length 17 miles; 500 shares of 125*l.* each; dividend 6*l.* per share.

Shropshire runs from the Dormington canal into the river Severn; length, 7½ miles; completed in 1792. 500 shares of 125*l.* each; dividend 4*l.* per share.

Somerset connects several of the collieries of this country with the Kennet and Avon canal; length 9½ miles; 800 shares of 150*l.* each; dividend, 9*l.* 10*s.* per share.

Staffordshire and Worcestershire connects the Trent and the Mersey canal with the river Severn at Stourport; length 46½ miles; completed in 1772; 700 shares of 140*l.* each; dividend, 40*l.* per share.

Stratford-upon-Avon connects Stratford with the Worcester and Birmingham Canal; length, 23½ miles; 2647 shares of 75*l.* 10*s.* each; dividend, 2*l.* per share.

Stourbridge connects that place with the Staffordshire and Worcestershire Canal. 300 shares of 145*l.* each; dividend, 12*l.* per share.

Stroudwater runs from the river Severn, near Framibrad, Gloucestershire, joining the Thames and Severn Canal, near Stroud; length, 8 miles. 200 shares of 150*l.* each; dividend, 24*l.* per share.

Swansea connects Swansea with Pen Tawe, Breconshire

length, 17 miles; completed in 1798. 533 shares of 100*l.* each; dividend, 15*l.* per share.

TAVISTOCK connects Tavistock with the river Tamar; length, with branch, 6 miles; completed in 1817. 350 shares of 100*l.* each; dividend, 2*l.* per share.

THAMES AND SEVERN commences near Stroud, where it joins the Stroudwater Canal, and unites with the Thames and Isis Navigation at Lechlade, in Gloucestershire; length, 30 miles; completed in 1789. 2450 shares of 100*l.* each; dividend, 1*l.* 10*s.* per share.

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TRENT AND MERSEY, OR GRAND TRUNK, commences at the union of the Derwent and Trent, and runs into the Duke of Bridgewater's Canal, at Preston Brook, communicating in its course with several other Canals; length, 93 miles; completed in 1777. 2,600 shares of 50*l.* each; dividend, 32*l.* 10*s.* per share.

WARWICK AND BIRMINGHAM connects the former place with the Birmingham Canal; length, 22½ miles; completed in 1799. 1,000 shares of 100*l.* each, and 1,000 of 50*l.* each; dividend, 15*l.* per cent. upon the amount paid up.

WARWICK AND NAPTON connects the preceding with the Oxford Canal, at Napton; length, 14 miles; completed in 1799. 980 shares of 100*l.* each; dividend, 12*l.* per share.

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WISBEACH connects the river Nene, at Wisbeach, with the old river at Antwell; length, 6 miles. 120 shares of 105*l.* each.

WORCESTER AND BIRMINGHAM commences at Birmingham, where it joins the Birmingham Canal, uniting with the river Severn, near Worcester; length, 29 miles; 6,000 shares of 78*l.* each; dividend, 4*l.* per share.

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